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An Experimental Analysis of Certain Factors Affecting Growth of Goldfishes in Homotypically Conditioned Water[1]

By Wayne F. Livengood

EARLIER work, reviewed critically by Allee (1931), demonstrated that crowding of fish or placing them in water in which many individuals have lived until it is what might be called over-conditioned, has a retarding effect on the growth of fish. More recently, Allee, Bowen, Welty and Oesting (1934) and Allee, Oesting and Hoskins (1936) have shown that under certain conditions, homotypically conditioned water, that is, water in which other fish of the same species have lived, can promote rather than retard growth, at least of the species of fish which have been experimentally tested. Much of this work has been done with the common goldfish, *Carassius auratus*.

The present series of experiments has been done, in part, at the same time, in the same laboratory, and except as noted hereafter, with the same methods as those upon which the 1936 report of Allee and associates was based. A mutual exchange of findings by all those working on the problem in this laboratory has made possible a more closely organized attack. The present work has centered primarily on the food values of conditioned water and has contributed to the solution of the following questions:

(1) Can similar results be obtained by an independent worker with a synthetic pond water that contained twice the salt concentration used by Allee and associates?

(2) Is the conditioning factor more effective, or less effective, when fish are fed in clean, unconditioned water?

(3) Does the oxygen content of the water affect the rate of growth of fish under the conditions of these experiments?

(4) Can similar growth-promoting effects be produced by direct food-conditioning of the water as by using fish-conditioned water?

Other problems on which investigation was begun, but on which discussion is reserved for the present, include a possible seasonal variation in growth and whether the growth-promoting power of fish-conditioned water, repeatedly found for synthetic pond water, can also be demonstrated for water from Lake Michigan.

Methods

All growth assays lasted from 20 to 30 days. All assay fish and conditioning fish were fed the same diet for any one day except when one or the other or both were purposely starved. Otherwise all were placed in contact with specially introduced food for 2 hours daily. When assay fish were fed, they were always given more food than they ate during the feeding period. The diets used consisted of *Daphnia*, ground rolled oats together with a

[1] This work was done in part at the same time as, and in connection with, work on the growth-promoting properties of fish-conditioned water reported by Allee, Oesting and Hoskins (1936). Appreciation is expressed to Dr. W. C. Allee for his advice and criticisms and to Dr. R. B. Oesting and Mr. W. H. Hoskins for their cooperation and assistance. Thanks are also given to Grassyfork Fisheries, Inc., Martinsville, Indiana, for several lots of goldfish sent gratis for this work. The article is printed under the grant from the American Wildlife Institute for the publication of biological contributions fundamental to fish management.

prepared fish food[2] fed half and half, ground rolled oats alone, and ground fresh beef liver. In the latter part of the work, an attempt was made to confine the diet for one experiment to one food; ground liver has been much used as this single food. If, as indicated by the reports of Allee and associates, suspended regurgitated food materials or particles from feces of fish in the conditioned water are of importance in promoting growth, it becomes necessary, as an analytical aid, to restrict the diets as much as possible.

In all experiments with fish-conditioned water, 22 liters of the water was conditioned for 22 hours by 8 fish which ranged from 60 to 75 mm. in length. When 45 liters were conditioned, 16 such fish were used as conditioning agents. This gave a conditioning coefficient (average length in mm. times number of conditioning fish divided by volume in liters) of from 21 to 27, the same conditioning strength most used by Allee and others (1936).

All growths given in this paper are for length only and are based on measurements of photographs taken before and after the assay period (according to the method described by Allee and associates, 1934). Since the photographs are slightly enlarged, the growths are given in artificial units which can be changed to actual growth in mm. by multiplying by 0.82. One-gallon stoneware jars have been used throughout as containers for the assay fish and in the later work, larger, similar stoneware jars have been used for conditioning tanks also. The assay jars contained 2 liters of water which was changed and the jars were washed and dried daily. The number of assay fish in all experimental and control sets was originally 10; not all survived and, of course, only the growth of surviving members was considered.

Throughout these experiments a synthetic pond water developed by Allee and his associates has been used. It was made up as follows: $CaCl_2$, 200 mg.; K_2SO_4, 100 mg.; $NaNO_3$, 100 mg.; $MgSO_4$, 100 mg., per liter of high grade distilled water. "C.P." and "Reagent" grade of salts were used exclusively. Allee and others (1934, 1936) diluted this to half strength, but I have used full strength.

In the preparation of food-conditioned water, about a tablespoonful of the food to be used was placed inside a bag of cotton cloth, with sixty threads to the inch. The bag was suspended in 22 liters of synthetic pond water and squeezed, forcing out juices and small particles of food. In the earlier work such water was allowed to stand 22 hours before using; later it was prepared and used immediately. The food-conditioned water was opalescent and its color depended on the kind of food used. Such water was portioned out to the isolated assay fishes either before or after passing through a phospho-bronze sieve with 325 meshes to the inch. This sieve allowed particles of about 40 *micra* to pass. The fish-conditioned water was also used with and without such sieving.

Presentation of Data

Doubling the Concentration of Electrolytes.—Three paired experiments were done in which the fish-conditioned water was siphoned directly into the assay jars without any attempt to remove feces or other suspended particles. The 29 assay fish grew, on the average, 2.00 units in length as compared with a mean growth of 0.4 units for 30 controls. The difference of

[2] This prepared food was made in the laboratory and consisted of ground liver, shrimp, eggs, flour and salts. It was prepared, dried, and fed in a dry form.

1.6 units has a high statistical probability with $P = 0.0001$.[3] In 8 experiments with sieved fish-conditioned water, 72 surviving experimental fish, from an initial 80, and 44 surviving control fish, from an initial 50,, showed a mean growth of 1.7 and 1.0 units respectively. The difference of 0.7 units is clearly significant, for $P = 0.0072$. These results are wholly similar to those obtained by others in this laboratory using similar methods but with half the electrolytic concentration of the same salts in the synthetic pond water.

Feeding in Fresh Control Water.—Without a direct test, it is impossible to state whether the effectiveness of the conditioned water lies in its being continuously present or whether it, perhaps, is potent solely because it is taken into the alimentary tract along with the food ingulfed during the daily feeding period. Accordingly, control fish in unconditioned water and experimental fish in similar but fish- or food-conditioned water were fed daily in freshly prepared, uncontaminated water to remove them from contact with any trace of conditioned water while feeding. Four paired experiments were made in which controls were fed in such fresh, unconditioned water, and the resulting growth was compared with that of a similar lot of control fish fed in the water in which they had been living for the preceding 22 hours; such water became self-conditioned and had a conditioning coefficient of about 20. A mean growth of 0.49 and 0.46 units, respectively, was determined for the 36 surviving fish that were fed in the fresh control water, and the 35 survivors that were fed in water in which they had lived for a day. The difference of 0.03 units is insignificant.

In 3 paired experiments involving fish in sieved, food-conditioned water, 29 fish survived when fed in fresh, uncontaminated water, and 25 lived through the experiment when fed as usual in the water in which they had been living for a day. The mean growth was 1.72 and 1.49 units respectively; the difference of 0.23 units is insignificant. In 2 experiments, in sieved, fish-conditioned water, 17 fish survived when fed as usual and the same number lived when fed in fresh uncontaminated medium. The mean growth was 1.15 and 1.20 units respectively; the difference of 0.05 units, again is not significant. All the evidence we have is against the assumption that goldfish take in a growth promoting substance from food or fish conditioned water at the time of feeding only. It is scarcely necessary to remark that the differences in numbers surviving the different treatments have no statistical significance; they are given in detail merely to show the extent of the experimentation upon which these conclusions are based.

Oxygen Tension in Relation to Fish Growth.—Early work indicated that the method of siphoning water to the assay jars affected the amount of dissolved oxygen by as much or more than 1 cc. per liter. In food-conditioning, as might be expected, the more food particles added, the less dissolved oxygen was present at the end of the experiment. Further tests showed less dissolved oxygen in similar water in summer than in winter due to temperature differences. Since for all these reasons, the amount of dissolved oxygen present varied considerably during the course of these experi-

[3] Statistical probability (calculated by "Student's" Method) is given in terms of P. The upper limit of statistical significance is indicated when $P = 0.05$; this value is equivalent to a difference 3 times the probable error of the difference, and can be read as meaning that there are 5 chances in 100 of the same difference being obtained by random sampling. The smaller the value of P, the greater is the statistical significance.

ments and since less oxygen tended to be present in the conditioned water than in controls, direct tests were made to find whether the rate of growth might be affected by this conditioning factor. In 3 paired experiments that involved 27 fish in aerated, fish-conditioned water and the same number in similar but non-aerated water, growth was 1.68 and 1.91 units respectively. The difference of 0.23 units is not significant. The oxygen tension in the aerated, fish-conditioned water was on the order of 4.19 cc. per liter while that in the non-aerated water, sampled approximately one-fourth of the distance from the surface to the bottom, was about 1.24 at the beginning of the assay day and 3.58 cc. per liter at its close. It should be noted that the fish had free access to the surface of the water where they could obtain more oxygen than if confined well below the surface. As is well known, goldfish are highly resistant and are capable of obtaining oxygen from the surface film.

In all experiments in which the water was food-conditioned, the dissolved oxygen present was low at all times. In one set of tests, it averaged 1.96 cc. per liter at the beginning of the assay day and 0.71 at its close. Values as low as 0.17 cc. per liter have been found. As will be shown in the following section, fish isolated into such food-conditioned water grew significantly more than their controls in untreated water with high oxygen content. All of the data collected on this point show that within the wide limits tested in these studies there are no indications that oxygen tension is important as a direct causal factor in the growth of goldfish under the conditions obtaining in these experiments.

Food-Conditioned Water and its Effect on Growth.—The methods used in preparing food-conditioned water have been outlined earlier. In the first work on this type of water, one experiment was made in which the conditioned water was not sieved through the phospho-bronze screen to remove the largest particles. There were 10 fish each in the experimental and control series. The mean growth was 2.50 and 0.44 units respectively; the difference is 2.06, with $P = 0.0052$. In 7 such paired experiments done with sieved food-conditioned water, there survived in the food-conditioned water 61 assay fish whose growth may be compared with that of 77 accompanying controls. The mean growth was 1.5 and 0.7 units respectively. The difference of 0.8 units greater growth in the food-conditioned water was a P value of 0.0001. Statistically these data are highly significant. When the assay fish were starved, those placed in the sieved, food-conditioned water grew significantly more than did a small lot of accompanying starved controls in sieved, unconditioned water. The 10 starved fish, which survived from 20 started, in the food-conditioned water grew 0.62 units while the 15 controls (20 at the beginning) decreased in length an average of 0.57 of a unit; the difference of 1.19 units has a P value of 0.0004. Evidently some of the fish were able to utilize food particles which had passed through a cloth with 60 meshes to the inch and a sieve which allowed particles of about 40 micra to pass.

Discussion

In attempting the interpretation of the effect of conditioned water upon the growth of fish, data presented by Allee and associates (1934, 1936) will be considered in addition to that published here for the first time. In this

whole investigation to date, fish-conditioned water has been assayed for its effect on growth of fish isolated into it under the following conditions: (1) Such water from fed conditioning fish has been used (a) with nothing removed; (b) with particles larger than about 40 micra screened out; and (c) after filtering through one thickness of Whatman No. 40 or two thicknesses of S. and S. No. 595 filter paper. (2) The conditioning fish have been starved from 5 to 15 days. (3) An extract from the skin of other fish has been added in place of other conditioning. Data for 1c, 2 and 3 are taken entirely from the work of Allee and associates.

My work with 1a and 1b support the other reports from this laboratory even though the present experiments were made in a synthetic pond water with twice the concentration of electrolytes used by other workers here.

Food conditioned water has been used (a) when it included all particles that would pass a cloth screen of 60 meshes to the inch and (b) when such water was further treated to remove particles larger than about 40 micra in diameter. The latter has been assayed both with fed fish and with fish which were starved during the growth assay. Experiments which I attempted on removing more and more of the particles from such food-conditioned water (a) by filtering through filter paper and (b) by filtering through a stone filter have not been included because of evidence of a high degree of toxicity, presumably from food decomposition products, such that in the most extreme case, only 5 of 40 experimental fish survived exposure to the filtered water while 35 of the accompanying 40 control fish lived through the growth assay.

It should be noted that throughout the present series of experiments the number of fish surviving until the end of the assay periods has been generally less than with other experiments in this laboratory. Except with these toxic filtrates there is no evidence of significant differential survival between the different parts of any given experiment or of any series of experiments. By removing visible food particles from conditioned water, we are presumably not removing all organic matter. Whether the remaining material is present in solution or in colloidal suspension is probably an important factor in the effect on growth (see Gellis and Clarke, 1935). Microscopic examination showed that even in the conditioned water which was filtered through paper, food particles were present. The total amount of organic matter is indicated by finding the so-called "required oxygen" according to the method given in *Official and Tentative Methods of Analysis* of the Association of Official Agricultural Chemists (1925: 87). The boiling with the oxidizing agent used, potassium permanganate, was limited to 10 minutes. Average results are summarized in Table 1.

As shown by Hoskins' experiments in which the conditioning coefficients are known to have been similar, the fasting fish put much less organic material into the water than do fish which are fed daily. Filtering removed approximately half of the organic stuff present in these waters. Food-conditioning, as practised by the writer, adds decidedly more organic material than does the usual type of fish conditioning. Whenever tested, the control (unconditioned) water showed no organic matter.

How does the growth-promoting effect of these different waters compare with the amount of organic material present? Here one must urge caution.

In order to be conclusive for comparative purposes, experiments should be made simultaneously, or there should be some uniform standard throughout by means of which different results can be compared with each other. Unfortunately, with the data at hand, neither practice was followed through the whole range of experiments. Taking those cases where fair comparisons can be made, it has already been reported (Allee and others, 1936) that the growth recorded for assay fish placed in sieved conditioned water from fed and starved conditioning fish showed a slight positive correlation with the amount of organic material present ($r = 0.066 \pm$ a standard error of 0.021). The same authors found greater difficulty in demonstrating increased growth in conditioned water when the water was filtered and when it was conditioned by fasting fish, although careful work revealed significant differences under both of these conditions.

TABLE 1. MEAN VALUES OF OXYGEN IN MG. PER LITER REQUIRED TO OXIDIZE ORGANIC MATERIAL IN CONDITIONED WATERS, TESTED AT 10 TIMES THE ASSAY STRENGTH BUT GIVEN HERE AT ASSAY STRENGTH.

Type of Water	Treatment	Required O_2	Conditioning Coefficient	Observer
Conditioned by fed fish	Sieved	0.7	21–27	Livengood
	Sieved	0.9	13–74	Hoskins
	Filtered	0.45–0.49	13–27	Hoskins
Conditioned by fish fed liver	Filtered	1.30	?	Oesting
Same water as above	Charcoal	0.17	?	Oesting
Conditioned by fish fed oats	Sieved	1.58	?	Oesting
	Filtered	0.68	?	Oesting
Conditioned by starved fish	Sieved	0.22	13–74	Hoskins
	Sieved	0.61	?	Oesking
	Filtered	0.12	13–27	Hoskins
	Filtered	0.29	?	Oesting
Food-conditioned water				
Oats	Filtered	1.12	.....	Oesting
Liver	Filtered	0.74	.....	Oesting
Mainly liver	Sieved	19.1	.....	Livengood
Control	Sieved	0.0	0.0	All observers

By making water extracts of food and by placing assay fish in such food-conditioned water, the present work demonstrates that growth was obtained, comparable in amount with that found in fish-conditioned water essentially like that used by Allee and associates. It is interesting to note however, that the total organic material present as measured by "required oxygen" is approximately 27 times greater for the food-conditioned water as used, than for the fish-conditioned water. In some ways, the conditioning fish are a device for introducing food particles, among other organic matter, into the conditioned water. There is evidence that the assay fish take up and use these particles from the water. The best of this evidence was furnished in the present studies when in food-conditioned water assay fish not otherwise fed during the entire test period, grew 0.67 of a unit while the accompanying starved controls decreased in length 0.57 of a unit, a significant difference.

The mechanism whereby the fish take up these small particles is not established. Certainly they are not taken merely when the fish is feeding in water containing such particles for the experimental and control fish alike grew as well when fed in clean, uncontaminated water as when given their daily feeding in conditioned water, and some of the starved fish grew when the daily feedings were omitted. Taken together with the work of Gellis and Clarke (1935) and that of Krizenecky (1926), these observations throw new light on the theory of Pütter regarding animal nutrition, and indicate that explorations should be made not alone of the feeding mechanisms involved but also of the size limits and concentration of particles that are effective both as supplementary feeding and as sustaining foods.

Two lines of evidence suggest that the added food value of the conditioned water is not the only growth-promoting factor acting in fish-conditioned water. The fact that similar increase in growth was produced by otherwise similar treatment when the food-conditioned water contained some 27 times the amount of organic matter as did the fish-conditioned medium is one. These experiments appear to be significant even though no attempt was made to find the limits of food-conditioning which would have a growth-promoting effect similar to that of fish-conditioned water. The other evidence is the repeated experience of Allee and his associates that a growth-promoting substance can be extracted from the skin of goldfish which is effective in solution in concentrations of 1 part in 200,000, in 400,000 or even in 800,000.

Summary

1. Assay fish grew significantly more in sieved, fish-conditioned pond water than did accompanying fish in similar, uncontaminated water. These results supported those of Allee and associates (1934, 1936), who used synthetic pond water of half the electrolytic concentration of that tested in these experiments.

2. Assay fish in similar food-conditioned water grew significantly more than did their accompanying controls.

3. Growth of control or of experimental assay fish fed in fresh control water is no different than when such fish are fed in the control, or conditioned water, in which they have lived for 22 hours. This means that the growth-promoting effect of the conditioned medium is not primarily a result of the ingestion, simultaneously with the introduced food, of organic material from the conditioned water.

4. While the growth-promoting effect of homotypically conditioned water can be equalled by adding minute particles of food directly to the water (food conditioning), the effect produced is not directly proportional to the amount of organic material added.

5. Variation in oxygen content, within the limits tested, appears to have no effect on growth under the conditions of these experiments.

Literature Cited

Allee, W. C.

1931 Animal Aggregations. A study in general sociology. Univ. of Chicago Press, Chicago: 431 pp.

1934 Recent studies in mass physiology. *Biol. Rev.*, 9: 1–48.

ALLEE, W. C., E. S. BOWEN, J. C. WELTY and R. OESTING
1934 The effect of homotypic conditioning of water on the growth of fishes and chemical studies of the factors involved. *Jour. Exp. Zool.*, 61: 185–207.
ALLEE, W. C., R. B. OESTING and W. H. HOSKINS
1936 Is food the effective growth-promoting factor in homotypically conditioned water? *Physiol. Zool.*, 9: 409–432.
ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS
1925 Official and tentative methods of analysis.
GELLIS, S. S. and G. L. CLARKE
1935 Organic matter in dissolved and in colloidal form as food for *Daphnia magna*. *Physiol. Zool.*, 8: 127–137.
KRIZENECKY, J.
1926 Ueber die nutritive Bedeutung der Wasser auígelosten organischen Substanzen für die Wassertiere. *Arch Hydrobiol.*, 16: 169–196.
PÜTTER, A.
1908 Die Ernahrung der Wassertiere. *Zeitschr. Allg. Physiol.*, 7: 282–320.

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New Fishes from the Templeton Crocker Expedition of 1934–35

By H. WALTON CLARK

DURING the Templeton Crocker Expedition of 1934–35, which so far as represented by specimens of fishes is concerned, began at Taio Hae Bay, Nuku Hiva Island, Marquesas, October 6, 1934, and ended in the neighborhood of Cocos Island off Costa Rica on March 27, 1935, several specimens were obtained of which no descriptions could be found in the literature available, and are therefore assumed to have been heretofore undescribed.

Among the small fishes taken about a submerged light was a number of specimens representing new species. Two of these were of such unusual interest that it was thought best to publish as promptly as possible. The descriptions follow.

FAMILY ATHERINIDAE: THE SILVERSIDES

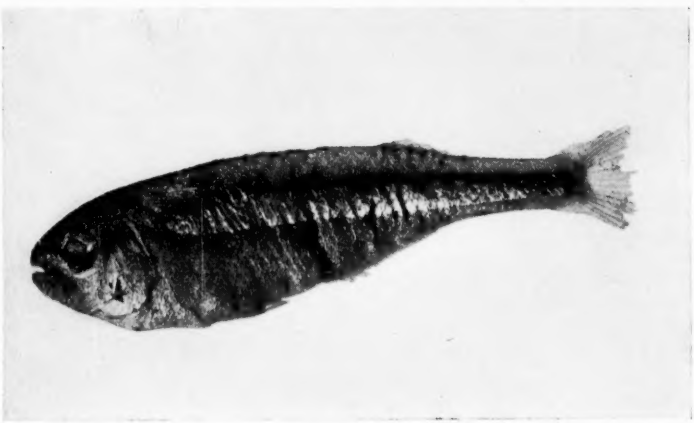
Notocheirus, new genus

An atherinid characterized by the absence of a spinous dorsal, by the position of the pectorals high up near the back, higher than eyes and above beginning of lateral stripe, and by the great depth of the compressed body anteriorly and the greatly elongate, rib-like, post-clavicles which almost meet at the ventral line anteriorly to support the deep sides. (Greek νῶτος, back, and χείρ, hand, from insertion of pectorals on back.) Genotype *Notocheirus hubbsi* Clark. The position of this remarkable species, so strikingly different from any other member of the family, was decided by Dr. Carl L. Hubbs, an authority on that group, and who suggested the appropriate generic name.

Notocheirus **hubbsi,** new species

Two specimens from Valparaiso Harbor, Chile, taken around light, Feb. 2–9, 1935, Templeton Crocker Exped., 1934–35. Specimens of about equal length. The paratype was cleared and an attempt made, with some success, to stain the skeleton according to the method of Hollister [Zoologica, 12 (10), 1934].

The following is a description of the holotype: Total length 44 mm.; body 40; head (9 mm.) 4.44 in body; depth (10) 4; eye (3.5) 2.7 in head; snout (2.9) 3.1; maxillary (4) 2.25, oblique, reaching about to middle of eye; interorbital (3.5) 2.7; D. 17, posterior, the length of its base (6 mm.) 1.5 in head, the rays rather short; A. I. 29, the origin well in advance of that of the dorsal, the length of its base equal to that of head: V. I, 4, abdominal, very short, their length 3 in head; P. very high, their origin well above the eye and upper edge of gill slit; the fins rounded and short, their length about 3 in head; caudal well forked; no lateral line; scales in about 12 cross series, 54 longitudinal, the scales deep, the exposed portion lozenge-shaped,



Notocheirus hubbsi
Holotype, body length 40 mm.

with a narrow thin posterior border, the surface of each scale beset with from 3 to 6 projecting spines; opercle and preopercle scaled; snout to nape velvety or bristly with spines like those on scales; jaws about equal; first part of gape short, horizontal, reaching half-way to eye, then descending obliquely along margin of maxillary; small but sharp conical teeth in the jaws, more or less concealed by the numerous spines of the snout; gill membranes free from the isthmus. Dorsal profile a gentle arch, ventral much more pronounced, deep forward where the sides are supported by the elongate rib-like post-clavicle.

Color in alcohol milky, a dark area on top of head, a broad silvery band with a black line above it extending from shoulder to base of caudal.

The clearing and staining of the paratype, while not remarkably success-

ful, due perhaps to its lengthy sojourn in preservative, showed the skeleton fairly well. The spines on the head and on the scales showed with marked distinctness and the elongate post clavicles, ribs, vertebrae, spines and rays showed clearly. Many of the anal rays were forked to the base. Counting these as single the number would be 23. Vertebrae 12 + 26 = 38.

HOLOTYPE.—No. 5525, Mus. Calif. Acad. Sci., Ichthyol., Valparaiso Harbor, Chile, Feb. 5–9, 1935; a paratype, No. 5526, same place and date.

Normanichthyidae, new family

Normanichthys, new genus

Nine little fishes, the longest about 74 mm. in total length, were taken about a submerged light in Valparaiso Harbor, Feb. 5–9, 1935, and resisted all attempts at identification with any species of which a description could be found. Specimens were accordingly sent to Dr. Carl L. Hubbs, of the Museum of Zoology, University of Michigan. Sometime thereafter Dr. Hubbs received from Dr. J. R. Norman, of the British Museum, what appeared to be a specimen of the same species. A specimen was accordingly sent to Dr. Norman for comparison with his material and it was ascertained that they were the same kind. Dr. Norman's largest specimen is about 120 mm. in total length, considerably larger than ours. The character of the genus can be best expressed in the comment of Dr. Hubbs regarding it:

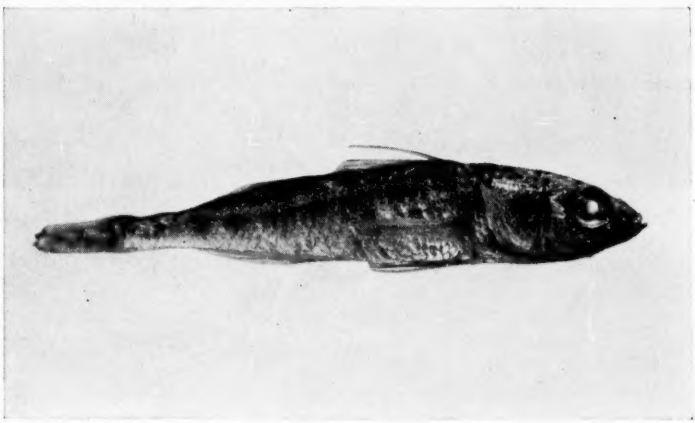
> I take this fish to be a modified percoid, perhaps nearest the Haemulidae. The I, 5 rayed thoracic pelvics, spinous dorsal, ctenoid scales, marginal premaxillary, 4 + 1 branchiostegals, free gill-membranes, well-developed pseudobranchiae, and other superficial characters point to a position within the Percoidea. The characters of the maxillary slipping under the preorbital, and of toothless palate, suggest Haemulidae. The spineless anal, excentric scales (focus near posterior border), flexible dorsal spines, lack of spines and serrations on head, reduced number of principal caudal rays (only 12), attenuate body, etc., are very distinctive.
>
> The little fellow has some superficial aspects at least of a resemblance to a number of Chilean and Antarctic types, from which, however, the short dorsal fins and posteriorly inserted pelvic fins set it off. Unless something near this fish exists of which I am ignorant I would say a new family would be needed for its sole reception.

Normanichthys ***crockeri,*** new species

Description of typical specimen: Total length 72.5 mm.; body 60; head (21 mm.) 2.85 in body; depth (12) 5; eye–snout (5) 4.2 in head; maxillary (6) 3.5, rather narrow, slipping partly under the rather narrow preorbital, slightly oblique and reaching about to pupil; premaxillary protractile, the tip of its peduncle fairly prominent between posterior nostrils; interorbital width (4) 5.2 in head, the center slightly concave; lower jaw slightly projecting; gill-membranes free from the isthmus, branchiostegals 4 + 1; D. XI–12; origin of spinous dorsal well behind that of ventrals and preceded by 9 scales, the spines very slender and flexible, the longest about 2 in head; second dorsal similar to the first, separated from it by 4 scales; A. 15, no spine present, similar to soft dorsal, its origin slightly in advance of the latter. Caudal truncate or slightly emarginate, the rays about 5–6, 6–5. Ventrals I, 5, thoracic, their origin slightly behind that of pectorals, rather narrow, their length about 2 in head, and reaching about halfway to vent; pectorals long and narrow, about as long as head and reaching nearly to vent; scales 4–48–8, finely and sharply ctenoid with minute weak teeth at the very margin, large,

rather rounded scales on opercle, preopercle and breast; fin membranes naked. Preopercle and opercle margins entire; pseudobranchiae rather small; gills 4, a slit behind last; gillrakers few, stout, digitiform, hispid. Several rows of small sharp teeth in jaws; none on vomer or palatines.

Color: Ground color of upper parts creamy, minutely punctate with numerous small dots over the scales. Shadowy masses of small dots form faint round blotches along middle of side; lower parts of side and belly unspotted. Dorsal fins and rays in a thickish spotted integument more or less obscuring character of spines; caudal rays thickly and heavily dotted; ventrals and anal pale, pectoral with a few spots.



Normanichthys crockeri
Holotype, body length 60 mm.

One of the specimens was dissected, and another was cleared and the skeleton stained. No air bladder noted; peritoneum black; intestine short, reaching when extended about to end of caudal and with 6 finger-like coecae at its junction with the stomach. Nothing satisfactory could be made out about the pharyngeal teeth or bones, except that the upper patches are elongate-ovate, the lower a narrow triangle. Vertebrae about $14 + 22 = 36$.

Dr. Norman adds that he is able to say from a dissection of the pectoral arch of one of his specimens, that the pelvic bones are attached to a process from the cleithrum, and that there are four flat plate-like radials, all firmly united to one another, and two are on the hypercorocoid (or scapula) and two on the hypocoracoid.

HOLOTYPE.—No. 5519, Mus. Calif. Acad. Sci., Ichthyol., around light Valparaiso Harbor, Chile, Feb. 5–9, 1935. One paratype, No. 5517, was sent to the Museum of the University of Michigan, one, No. 5518, to the British Museum. The others, Nos. 5520 to 5524 inclusive, are retained.

Many thanks are due to the kind assistance of Dr. G. D. Hanna and Mr. F. L. Rogers in the preparation of the photographs.

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Geographical Variation and Correlation in Pacific Flounders[1]

By Lawrence D. Townsend

In another publication (Townsend, 1936) the author has presented data for the study of variations of meristic characters in flounders which are known to occur in the northeastern Pacific from Puget Sound, Washington, to Pavlof Bay, Alaska. At the time of this publication it was noted (p. 7) that for certain species these data gave evidences of geographical races that could be characterized by differences in the mean of one or more of the meristic characters studied. It will be the purpose now to examine the data given to determine in what species and to what extent it is possible to distinguish these races. At the same time the pronounced correlations existing between the number of dorsal and anal fin rays will be discussed.

As the basis for this study we have the data which were given in detail in the previous report in Table 4, "The counted frequencies of dorsal fin rays in the flatfishes from different parts of the North Pacific," and Table 5, "The counted frequencies of anal fin rays in the flatfishes from different parts of the North Pacific," and the original data from which was compiled Table 6, "The frequency distributions of the total number of vertebrae in Pacific flatfishes for all samples and species." As these tables are too bulky to reproduce in full, the reader is referred to them for the actual tabulations of frequencies. The analysis of geographical variation will be confined to the localities Nos. 1 to 17 under Tables 1, 4 and 5. The data for the correlation of characters were obtained from the original tabulations of numerical counts.

Geographical Variation in Pacific Species

Numerous attempts have been made to establish geographical varieties or races of fish on the basis of characteristic variations in the numbers of fin rays, vertebrae, color bars or spots, gill-rakers, pyloric caeca, or rows of scales. The same problem of distinguishing races has been studied by determining characteristic body proportions, age compositions, spawning times and spawning reactions, but since the present data refer principally to variation in meristic characters, these other methods of racial analysis need not concern us.

On the Pacific, racial work has not played an important rôle to date in fisheries investigations and has not yet become the source of controversy, such as has marked racial studies in other regions, particularly northern Europe. The following brief list of works involving studies of meristic characters of Pacific fish is intended to be somewhat representative of the different species upon which such work has been carried out and not in any sense to be a review of this literature, which subject is beyond the scope of this paper. The Pacific herring was studied by Thompson (1917), Hubbs (1925) and extensively by Rounsefell (1930), Rounsefell and Dahlgren (1932, 1935) and Tester (1936). Hubbs (1925), Hart (1933) and Clark (1936) investi-

[1] A contribution from the Department of Zoology, University of Washington, and the International Fisheries Commission, Seattle, Washington.

gated the California sardine (British Columbia pilchard). Other representative works on geographical variations of meristic characters of fishes of the northeastern Pacific are: Eigenmann (1895) on *"Leuciscus"* [*Richardsonius*][2], Rutter (1896) on sticklebacks, Hubbs (1921b) on *Leptocottus,* (1925) on the California anchovy and (1927) on several blennies, McGregor (1924) on king salmon, Schultz and Welander (1934) on *Hemilepidotus* and (1935) on *Theragra,* Smith (1936) on *Parophrys,* and Schaefer (1936) on *Hypomesus.* Jordan (1891) extended the observations on geographical variations in the number of vertebrae to include those in related species of fish inhabiting different localities.

The work of these investigators has the common result, that when significant geographical variations in the meristic characters of Pacific fishes have been demonstrated, these variations tend toward an increase in the number of fin rays or vertebrae in northern samples of fish. A tendency to develop a general law of variations as a function of latitude is met by the contrary results obtained by Hubbs (1921a) and Schultz (1927) on the golden shiner, in which species it was observed that northern specimens had fewer anal fin rays than southern ones. McGregor's (1924) observation of more caeca in southern king salmon than in northern cannot be adequately interpreted on the basis of present knowledge of variations in such organs.

The result of the present work on flounders indicates that the species studied conform with most of the previous results on Pacific Coast fishes in that an increase in the number of fin rays and vertebrae in northern localities is indicated. The data for geographical variations are confined to the species *Lepidopsetta bilineata, Platichthys stellatus* and *Hippoglossoides elassodon* (designated in the tables of the previous report by the letters "J," "O," and "F" respectively). The means for the several characters have been compared for each species for the locations listed in the original reference, and are given here in Table 1. Except for *H. elassodon* we see that there are no significant differences among the means of the characters for the various Alaska samples. This lack of differentiation in the Alaska samples of these species has permitted grouping the Alaska data for purposes of comparison with the Puget Sound samples.

It is seen that the numbers of rays in the dorsal and anal fins in each species differ significantly in the fish from Puget Sound and Alaska samples. In *Hippoglossoides elassodon* this difference also holds between certain Alaska samples. In *Hippoglossoides* a similar significant difference is further found in the number of vertebrae. We may note also that the other species have slightly increased vertebrae in the fish of the northern samples, and that in *H. elassodon* there is a progressive increase in the number of dorsal and anal rays in the fish of the samples farther to the westward. The differences in 1 or more characters of the 3 species, when compared with the probable errors of the differences between localities, are sufficient to indicate racial separation of the stocks of these 3 species in Alaskan waters and in Puget Sound. It is not improbable that with samples of sufficient size to permit analysis on an age basis, still more definite racial differences would be discovered.

[2] Dr. Carl L. Hubbs has kindly determined the modern generic names, given here in brackets, for those used by previous authorities.

Without entering the controversy of what constitutes a "race" or geographical variety, this term is used here to designate a population of fish which can be distinguished from another population of the same species by a difference, significant by statistical criteria, in the mean of one or more meristic characters.

For *Lepidopsetta bilineata* and *Platichthys stellatus* our samples in western Alaska are grouped for an area separated by a great distance from the locality of the Puget Sound samples with which they are compared. In *Hippoglossoides elassodon* the localities for the Alaska samples are spread out along the coast from Yakutat in the central part, to Hook Bay in the western part. The regular increase in number of meristic characters toward the west and north noted in the samples of this species indicates that the differentiation of racial characteristics is a regular process along our coast. It seems altogether probable that if more extensive data from many points on the Pacific Coast were available for some widely distributed species of flounder, a continuous gradation would be found to occur in the number of meristic characters of the populations along the coast. But for the present we can say that on the basis of the number of fin rays and vertebrae, populations of these 3 species in western Alaska are racially distinct from those in Puget Sound.

In addition to the evidences for geographical variations in the 3 species given above, certain columns of frequencies in Tables 4 and 5 (Townsend, 1936) exhibit slight tendencies toward similar variations in other species. These data, due to small samples and the extent of the variations, are not amenable to the present form of statistical analysis and we shall, therefore, consider only the actual frequencies as they are found in the tables. From these figures we may note that *Psettichthys melanostictus* exhibits a definite increase in the number of rays in both dorsal and anal fins in the northern samples of fish; the 8 counts of dorsal rays for Alaska specimens are all greater than the mean for Puget Sound, and the 7 counts for anal rays are also all greater than the mean of Puget Sound specimens. *Microstomus pacificus* shows a somewhat smaller increase, but the mean number of rays in both dorsal and anal fins is greater for the Alaska sample. The single individual of *Citharichthys stigmaeus,* which was taken far north of the center of its known range, shows very high counts of both dorsal and anal rays in comparison with that of fish from Puget Sound. The other species in which there are samples from both Puget Sound and Alaska do not demonstrate any appreciable geographical differences in the number of fin rays. These small samples may be taken to indicate differences in these species of the same kind as that shown for the 3 species for which larger samples are available.

Another variable character in *Platichthys stellatus* that shows geographical differences is the location of the eyes and pigment (on the right or left side). In this feature the proportion of the populations having the eyes and coloration on the left side (so-called reversed specimens) increases towards the north. Gudger (1935) in summarizing the published records of reversed specimens of flatfishes has referred to the observations of Hubbs, as mentioned by Norman (1934: 28), that this species in California is about 50% reversed, in Alaska 75% and in Japan practically 100%. Gudger (1935:

TABLE 1. COMPARISON OF THE MEAN NUMBER OF RAYS IN THE DORSAL AND ANAL FINS AND THE MEAN NUMBER OF VERTEBRAE IN FLOUNDERS FROM PUGET SOUND AND DIFFERENT LOCALITIES IN ALASKA

Species and Locality	No.	Mean No. of Rays	P.E. Mean	Diff. / P.E. Diff.
		Dorsal Rays	±	
Platichthys stellatus (O)[a]				
Puget Sound (1)	203	58.53	.10	12
Alaska (3)	113	60.58	.14	
Lepidopsetta bilineata (J)				
Puget Sound (1)	233	74.88	.11	9.5
Alaska, all samples	496	76.11	.07	
Baralof Bay (16)	88	75.84	.16	
Northeast Harbor (17)	122	76.43	.15	
Kodiak Island (8, 9)	7	76.29	.56	
Boulder Bay (14)	16	76.12	.48	
Mitrofania Bay (13)	52	75.52	.23	
Cold Bay (10)	203	76.20	.11	
Minor (11, 12, 15)	8	75.88	.66	
Hippoglossoides elassodon (F)				
Puget Sound (1)	59	80.32	.35	2.3[b]
Alaska, all samples	172	81.19	.15	
Yakutat Bay (5)	104	80.53	.19	
Zaikof Bay (6)	22	81.14	.32	
Kodiak–west (8–17)	46	82.93	.27	
		Anal Rays		
Platichthys stellatus (O)				
Puget Sound (1)	208	42.12	.07	7
Alaska (3)	114	42.96	.10	
Lepidopsetta bilineata (J)				
Puget Sound (1)	232	57.37	.17	7.4
Alaska, all samples	495	58.70	.06	
Baralof Bay (16)	88	58.82	.14	
Northeast Harbor (17)	120	59.15	.14	
Kodiak Island (8, 9)	7	58.71	.49	
Boulder Bay (14)	16	58.94	.26	
Mitrofania Bay (13)	50	58.64	.20	
Cold Bay (10)	206	58.39	.09	
Minor, (11, 12, 15)	8	58.50	.46	
Hippoglossoides elassodon (F)				
Puget Sound (1)	60	62.55[c]	.28	3.3[b]
Alaska, all samples	171	63.57	.13	
Yakutat Bay (5)	103	63.08	.15	
Zaikof Bay (6)	22	63.50	.33	
Kodiak–west (8–17)	46	64.72	.25	
		Vertebrae		
Platichthys stellatus (O)				
Puget Sound	133	35.31	.01	1.2
Alaska	106	35.36	.04	
Lepidopsetta bilineata (J)				
Puget Sound	135	39.42	.03	1.2
Alaska, all samples	359	39.46	.01	
Baralof Bay	88	39.48	.04	
Northeast Harbor	115	39.53	.04	
Kodiak Island	18	39.28	.08	
Boulder Bay	16	39.56	.08	
Mitrofania Bay	52	39.46	.05	
Cold Bay	64	39.38	.04	
Minor	6	39.		
Hippoglossoides elassodon (F)				
Alaska	30	44.40	.08	7
Puget Sound	62	43.68	.07	

[a] Letters and numbers in parentheses designate the column headings in which the frequencies are to be found in the original tables (Townsend, 1936).

[b] The index of significance for the differences between the means of the Yakutat and Kodiak samples is 7 for the dorsal rays and 5.5 for the anal rays. The corresponding index for the differences between the means of the Puget Sound and Kodiak samples is 6 for dorsal rays and 6 for the anal rays.

[c] This mean is incorrect as given in Townsend (1936).

20) gives Parker (1903) credit for first recording the reversal of *Platichthys* but he failed to mention the well-known record of one of the earliest authors to work upon Pacific flatfishes, who was probably the first to record color reversal in a number of individuals of this species. Indeed, Lockington's records[3] (1880) constitute as far as known the largest number of specimens upon which the actual numbers comprising the full data have been published to date. Lockington (p. 93) reported on 282 individuals of *Platichthys stellatus* in three San Francisco fish stalls, of which 54.6% were sinistral.

Barring the possibility of selection on the part of fishermen or handlers of the fish, these data, if the size of the sample is considered to be sufficient for significant results, indicate that the proportion of reversed specimens of *Platichthys stellatus* found in the San Francisco markets of 1879 was over 50%; a figure very slightly greater than that for the proportion to be reported below for samples from Puget Sound.

Of the 530 specimens of *Platichthys* from Puget Sound examined as to this feature 259 (47.9%) were dextral and 271 were sinistral, whereas of the 3196 specimens tabulated from Alaska 1052 (32.9%) were dextral and 2144 were sinistral. The locations from which they were taken are given in Townsend (1936, Table 2). In addition 3081 specimens were observed at Larsen Bay, Alaska, during the summers of 1935 and 1936, most of them from trap catches in Uyak Bay; and the data for Puget Sound include observations from the records of Richard T. Smith and D. W. Erickson.

The detailed counts for this characteristic given in Table 2, in which the Alaska counts are segregated as to year and sample, show that even in the smaller of these groups, sinistral specimens are nearly always twice as common as dextral ones; in most counts of 50 or more fish the percentage of reversed or sinistral individuals was remarkably close to 67. This is somewhat less than the percentage quoted by Norman and Gudger for Alaska samples, but it must be borne in mind that the present specimens preponderate from a single locality on Kodiak Island, and should not, therefore, be considered as characteristic of all Alaska.

When the difference between Puget Sound and Alaska samples are judged by applying the X^2 test, it is found that possibilities are fewer than one in one million of a chance variation occurring as great as that observed. Comparison of the smaller samples from Puget Sound and Alaska, wherein the data have been arranged according to sex, indicates that no significant differences are to be found between the proportions for the two sexes. We may, therefore, consider that in *Platichthys stellatus* the proportion of the population that is colored dextrally is geographically variable and is, like the number of vertebrae and fin rays, a reliable racial character. The population of *Platichthys stellatus* in western Alaska, by reason of having a significantly higher percentage of sinistral individuals, constitutes a race distinct from that occurring in Puget Sound, and California, where sinistral and dextral examples occur in approximately equal frequency, and probably from that of Japan, where the reversed or sinistral condition is said to be nearly universal.

[3] His words: "The eyes and color are sometimes upon the right and sometimes upon the left side. Out of sixty-five individuals, which I counted as they lay upon the stall, thirty-two were colored upon the right and thirty-three upon the left side. On another occasion I counted seventy-five sinistral and fifty-eight dextral individuals, and on a third thirty-eight dextral and forty-eight sinistral."

TABLE 2. THE VARIATION IN THE SIDE COLORED OF *Platichthys stellatus* IN ALASKA AND PUGET SOUND FOR A SERIES OF OBSERVATIONS.

	Dextral	Sinistral	Total
Puget Sound			
Males	20	27	47
Females	26	22	48
Sex Unknown	213	222	435
Total for Puget Sound	259	271	530
Alaska, 1931, 1932			
Males	18	34	52
Females	16	38	54
Sex Unknown	3	6	9
Total for Alaska, 1931, 1932	37	78	115
Alaska, 1935			
Larsen Bay group	62	113	175
Larsen Bay group	58	99	157
Larsen Bay group	62	124	186
Larsen Bay group	4	14	18
Larsen Bay group	68	149	217
Larsen Bay group	7	24	31
Larsen Bay group	38	74	112
Larsen Bay group	16	13	29
Larsen Bay group	8	9	17
Larsen Bay group	6	19	25
Larsen Bay group	19	41	60
Larsen Bay group	6	10	16
Larsen Bay group	16	30	46
Larsen Bay group	5	8	13
Larsen Bay group	24	41	65
Larsen Bay group	11	20	31
Larsen Bay group	19	43	62
Larsen Bay group	3	22	25
Larsen Bay group	21	61	82
Larsen Bay group	4	12	16
Larsen Bay group	9	17	26
Larsen Bay group	17	41	58[a]
Total for Alaska, 1935	483	984	1467
Alaska, 1936			
Karluk Spit, June 1	8	17	25
Uyak Bay Traps, June 9	82	193	275
Uyak Bay Traps, June 13	266	515	781
Uyak Bay Traps, June 23	65	148	213
Uyak Bay Traps, July 7	56	109	165
Uyak Bay Traps, July 14	18	35	53
Uyak Bay Traps, July 15	28	58	86
Uyak Bay Traps, Aug. 1	9	7	16
Total for Alaska, 1936	532	1082	1614
Total for all Alaska material	1052	2144	3196

[a] The combination of ten groups, each of which was composed of ten or fewer specimens.

Most investigators of geographical variations have been inclined to accept thermal (or other hydrographic) conditions as being responsible for the observed variations. While nothing is known of temperature conditions during the development of Pacific flounders, except for the halibut, Rounsefell and Dahlgren (1932) were able to find a definite negative correlation between the air temperatures in the spawning season of the herring and the vertebra count. From the mass of evidence available it seems more than likely that most geographical variations in fish are to be correlated with some hydrographical conditions.

Correlation of Meristic Characters

A little worked phase of the field of variational studies in fish is the correlation of numerical characters. Correlations of size of organs or parts of organs have been developed very successfully in crustacea, especially in decapods (see particularly the elaborate work of Pearl and Clawson, 1907, on the crayfish) and in mammals, including man, but few investigations of this sort have been made on fishes. Studies of correlations of numbers of meristic organs in fish, still less frequent, are largely the result of the labor of Georg Duncker (1896, 1899, 1900, 1904). While much of his work was with correlations of the paired fins, which do not concern us, it is worthy of note that all of his studies of fin ray correlations show relatively high positive values. In this respect the data presented below exhibit the same characteristic.

The correlations of meristic characters of flatfishes to be reported have been developed in two ways. First has been the correlation in number of the rays of the dorsal and anal fins for the individuals within a species. In this analysis it is found that individuals with more dorsal rays than the average tend to have more anal rays and that, conversely, those with fewer dorsal rays have fewer anal rays. This type of correlation within a species is hardly applicable to the relationship of the number of rays in the dorsal and anal fins to the number of caudal rays or to the number of vertebrae, because the original data have established that the latter characters have very low variability. The second type of correlation has been that between the mean number of rays of the dorsal and anal fins in a series of species, and the correlation of these means with the mean number of vertebrae within a series of species. In this comparison it is found that species having relatively high mean numbers of dorsal rays tend to have high mean numbers of anal rays and vertebrae, and those with lower mean numbers of dorsal rays have lower mean numbers of anal rays and vertebrae; and the mean number of anal rays is also correlated directly with the mean number of vertebrae. More simply stated the first type of correlation is that between the variations of individuals from the mean of the species, and the second type is the correlation between the variations of species from the mean of a group of species.

The tendencies of meristic variations to occur in the same direction have been studied by the calculation of r, the coefficient of correlation. Table 3 gives the value of r as calculated for the correlation of the number of dorsal and anal rays for individuals of the species of Pacific flounders in which more than 40 specimens were examined. In every species thus studied, except *Atheresthes stomias*, the value of r is remarkably high. For each species the coefficient of correlation is at least 5 times as large as its probable error and is therefore significant. As far as known this is the first published mention, with detailed substantiating data, of such definite correlations in any fish from the North Pacific.

The coefficients of correlation exhibited in Table 3 establish the fact that there is a definite tendency within each species of Pacific flatfish for variations of the numbers of rays in the dorsal and anal fins to occur in the same direction and in nearly the same degree for all species for which there are sufficient observations.

TABLE 3. THE CORRELATION OF DEVIATIONS FROM THE MEAN NUMBER OF RAYS IN THE DORSAL AND ANAL FINS IN 14 SPECIES OF PACIFIC FLOUNDERS.

Species	No. of Specimens	Coef. of Correlation	P. E. Coef. Correlation
Lepidopsetta bilineata		+	±
Puget Sound	230	.650	.026
Alaska	490	.667	.017
Platichthys stellatus			
Puget Sound	201	.566	.032
Alaska	113	.538	.045
Hippoglossoides elassodon			
Puget Sound	58	.910	.015
Alaska[a]	170	.768	.021
Limanda aspera	150	.651	.032
Eopsetta jordani	66	.651	.048
Lyopsetta exilis	118	.609	.039
Glyptocephalus zachirus	96	.802	.024
Citharichthys stigmaeus	65	.698	.043
Atheresthes stomias	63	.444	.068
Microstomus pacificus	50	.881	.022
Parophrys vetulus	203	.696	.024
Isopsetta isolepis	110	.599	.041
Pleuronichthys coenosus	47	.732	.046
Psettichthys melanostictus	43	.824	.033

[a] The discrepancy in this species for the two localities is probably explainable by the heterogeneity of the Alaska material.

Beside the observations of Duncker (*loc. cit.*) of similar correlations in *Acerina, Pleuronectes* and *Cottus* and of correlations of the number of dorsal and ventral plates in *Zeus faber,* Moenkhaus (1897) observed correlations in the median fin elements in *Etheostoma* [*Percina*], and Punnett (1904) observed both positive and negative correlations in various vertebral elements in *Spinax* [*Etmopterus*]. In working over the data given by Eigenmann (1895) in his Tables on pages 14 and 15 I find that there is a high correlation ($r = +.682 \pm .043$) between the number of dorsal and anal rays in individuals of *Leuciscus.* In view of the fact that in every case under consideration there has been found a high positive correlation between the variation in the dorsal and anal fin elements, we may consider it probable that as a general rule where variation occurs in these structures there is a positive correlation between them.

The high correlations found to exist between the number of dorsal and anal rays of the individuals within a number of species furnished the original basis for supposing that the second type of correlation occurred, namely, that the mean number of dorsal and anal rays and vertebrae are correlated within a group of species. The means were first taken from Table 10 (Townsend, 1936), "Summary of the meristic characters studied in the flatfishes of the North Pacific," for 18 Pacific Coast species (*Inopsetta ischyra* omitted) and the following correlations calculated therefrom:

Dorsal and anal, $r = +.932, \pm.006$
Dorsal and vertebrae, $r = +.768, \pm.065$
Anal and vertebrae, $r = +.789, \pm.060$

The data for these correlations are shown as scatter graphs in Figure 1 where each cross in a section indicates a pair of mean characters for one species.

These correlations are so pronounced that it was decided to examine the

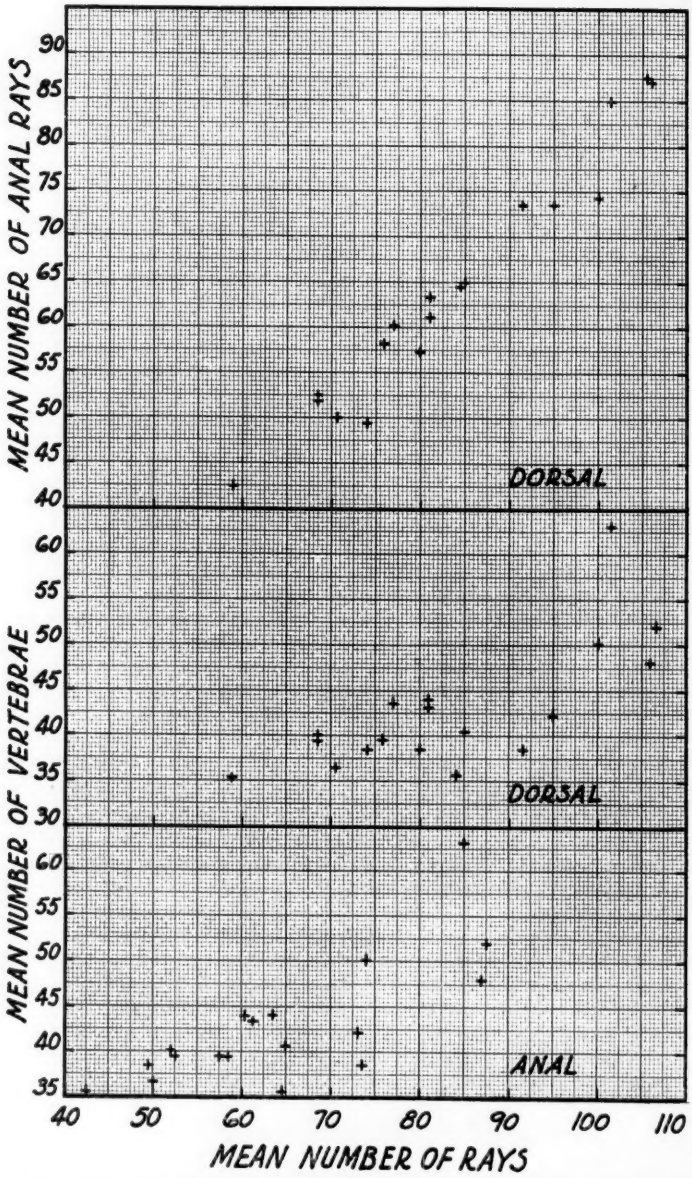

Fig. 1. The correlations of the mean number of anal rays with the mean number of vertebrae, of the mean number of dorsal rays with the mean number of vertebrae, and of the mean number of dorsal rays with the mean number of anal rays, in 18 species of flatfish from the northeastern Pacific.

matter further in a larger series of species. Accordingly, the data for the ranges of the dorsal and anal rays for 238 species of flatfishes as given by Norman (1934) were used. The data were selected from this monograph as follows: the ranges of dorsal and anal rays were taken with the exception of (1) species about which doubt is expressed in the text, (2) species in which only types are known, and (3) species which Norman did not examine and for which only a single count was recorded. The ranges for the number of rays of each fin were simply averaged and the correlation calculated from these averages. The inaccuracies inherent in this method of obtaining the average fin ray number are obvious but no better data on such an extensive series of flatfish species are available. It is to be regretted that in such an otherwise comprehensive work Norman neglected to include a larger number of vertebral counts, which might have permitted the further development of correlations between the median fin elements and the vertebrae.

For the entire series of 238 species we find the correlation of the mean number of fin rays in the dorsal and anal fins to be $r = +.856, \pm.011$. These species consist of one in the family Psettodidae; 150 in the family Bothidae, for which $r = +.920, \pm.009$; and 87 in the family Pleuronectidae, for which $r = +.954, \pm.006$. These very high correlations are rather astonishing. As Norman was quite liberal in accepting as separate species a number of rather vaguely distinguished forms, these correlations probably tend to be somewhat too high due to the favorable effect on the coefficient of correlation of a certain amount of duplicating observations. Even after making allowance for this fact, the correlations established for this series of data must be acknowledged as remarkably high.

As a definitely demonstrated fact it has thus been shown that a general tendency toward correlation in the deviations of the average number of rays in the dorsal and anal fins exists throughout the series of species of flatfish upon which such data have been assembled; this tendency is shown to exist within taxonomic sections of this series of species in approximately the same degree as for the entire group; and the tendency exists also in nearly the same degree in a smaller group of species, of mixed taxonomic relationships, but all having nearly similar distributions in the North Pacific.

It does not seem too early to summarize data on correlation of meristic characters, at least as they are found in flatfish, by saying that within species there is a pronounced positive correlation between the variation in number of dorsal and anal rays; that in groups of species, whether of close taxonomic relationship or not, there is a high positive correlation between the mean number of dorsal and anal rays; and it is probable that similar positive correlations exist between the mean number of dorsal and anal rays and the number of vertebrae. It is only logical to suppose that similar sets of correlations could be established for other great groups of species in other orders of fishes. The correlations already noted in *Cottus, Acerina, Zeus, Etheostoma* [*Percina*] and *"Leuciscus"* [*Richardsonius*] indicate that this phenomenon is widespread within species.

It seems that the principle that different meristic characters tend largely to vary in the same direction in individuals and in species has been very generally overlooked in studies of variations. Numerous isolated remarks, such

as that of Norman (1934: 47)[4] indicate that the phenomenon has been observed.

The more or less simultaneous differentiation of dorsal and anal fin anlage in the embryo must account for such widespread correlations of median fin elements. The universality with which this simultaneous formation of fin anlage occurs in a large number of species of pleuronectids emphasises this as a fundamental principle explaining variation in this group and it appears likely that the principle will readily extend to other groups of fish.

Literature Cited

Clark, Frances N.
1936 Variations in the number of vertebrae of the sardine, *Sardinops caerulea* (Girard). Copeia, 1936 (3): 147–150.

Duncker, Georg
1897 Korrelationsstudien an den Strahlenzahlen einiger Flossen von *Acerina cernua* L. *Biol. Centralbl.*, 17: 785–794, 815–831.
1899 Preliminary report on the results of statistical and ichthyological investigations made at the Plymouth Laboratory. *Jour. Mar. Biol. Assoc.*, (n. s.) 5: 172–175.
1900 Variation und Asymmetrie bei *Pleuronectes flesus* L. (Statistisch untersucht.) *Wiss. Meeresunt., Abt. Helgoland*, (n. s.) 3: 333–404.
1904 Symmetrie und Asymmetrie bei bilateralen Thieren. *Arch. Entw. Mech. Org.*, 17: 533–682.

Eigenmann, Carl H.
1895 *Leuciscus balteatus* (Richardson), a study in variation. *Am. Nat.*, 29: 10–25.

Gudger, Eugene W.
1935 Abnormalities in flatfishes (Heterosomata) I. Reversal of sides. A comparative study of the known data. *Jour. Morph.*, 58: 1–39.

Hart, John L.
1933 Statistical studies on the British Columbia pilchard: vertebra counts. *Tran. Roy. Soc. Can.*, 1933, Sec. 5: 79–85.

Hubbs, Carl L.
1921a Geographical variation of *Notemigonus crysoleucas*—an American minnow. *Trans. Ill. State Acad. Sci.*, 11: 147–151.
1921b The latitudinal variation in the number of vertical fin rays in *Leptocottus armatus*. *Occ. Pap. Mus. Zool. Univ. Mich.*, 94: 1–7.
1925 Racial and seasonal variation in the Pacific herring, California sardine and California anchovy. *Fish. Bull., Calif. State Fish and Game Comm.*, 8: 1–23.
1927 Notes on the blennioid fishes of western North America. *Pap. Mich. Acad. Sci., Arts and Letters*, 7: 351–394.

Jordan, David S.
1891 Relations of temperature to vertebrae among fishes. *Proc. U. S. Nat. Mus.*, 14: 107–120.

Lockington, W. N.
1880 Review of the *Pleuronectidae* of San Francisco. *Ibidem*, 2: 69–108.

McGregor, E. A.
1924 A possible separation of the river races of king salmon in ocean-caught fish by means of anatomical characters. *Calif. Fish and Game*, 9: 138–150.

Moenkhaus, William J.
1898 Material for the study of the variation of *Etheostoma caprodes* Raf. and *Etheostoma nigrum* Raf. in Turkey Lake and Tippecanoe Lake. *Proc. Ind. Acad. Sci.*, 1897 (1898): 207–228.

Norman, J. R.
1934 A systematic monograph of the flatfishes (Heterosomata). Vol. 1. Psettodidae, Bothidae, Pleuronectidae. British Mus. (N. H.), London: i–v, 1–459.

[4] "[As] the number of rays in the dorsal and anal fins is . . . subject to the same fluctuations [as vertebrae], the two characters may be considered together."

PARKER, GEORGE H.
1903 The optic chiasma in Teleosts and its bearing on the asymmetry of the Heterosomata (flatfishes). *Bull. Mus. Comp. Zool.*, 40: 221–242.
PEARL, RAYMOND, and A. B. CLAWSON
1907 Variation and correlation in the crayfish, with special reference to the influence of differentiation and homology of parts. *Carn. Inst. Wash., Publ.* 64: 1–70.
PUNNETT, R. C.
1904 Merism and sex in "Spinax niger." *Biometrica*, 3: 313–362.
ROUNSEFELL, GEORGE A.
1930 Contribution to the biology of the Pacific herring, *Clupea pallasii*, and the condition of the fishery in Alaska. *Bull. U. S. Bur. Fish.*, 45: 227–320.
ROUNSEFELL, GEORGE A. and EDWIN H. DAHLGREN
1932 Fluctuation in the supply of herring, *Clupea pallasii*, in Prince William Sound, Alaska. *Ibidem*, 46: 263–291.
1935 Races of herring, *Clupea pallasii*, in southeastern Alaska. *Ibidem*, 47: 119–141.
RUTTER, CLOUDSLEY
1896 Notes on freshwater fishes of the Pacific slope of North America. I. On the sticklebacks of California, with special reference to individual variations. *Proc. Calif. Acad. Sci.*, (2) 6: 245–254.
SCHAEFER, MILNER B.
1936 Contribution to the life history of the surf smelt (*Hypomesus pretiosus*) in Puget Sound. *Biol. Rep. Wash. Dept. Fish.*, 35B: 1–46.
SCHULTZ, LEONARD P.
1927 Temperature-controlled variation in the golden shiner, *Notemigonus crysoleucas*. *Pap. Mich. Acad. Sci., Arts and Lett.*, 7: 417–432.
SCHULTZ, LEONARD P. and ARTHUR W. WELANDER
1934 The cottoid genus *Hemilepidotus* of the North Pacific. *Jour. Pan Pacific Res. Ins.*, 9 (2): 5–6.
1935 A review of the cods of the northeastern Pacific with comparative notes on related species. COPEIA, 1935 (3): 127–139.
SMITH, RICHARD T.
1936 Report on the Puget Sound otter trawl investigations. *Biol. Rep. Wash. Dept. Fish.*, 36B: 1–61.
TESTER, ALBERT L.
1936 Some results of the British Columbia herring investigation and their economic bearing. *Rept. Brit. Col. Comm. Fish.*, 1935: L74–L80.
THOMPSON, WILLIAM F.
1917 A contribution to the life-history of the Pacific herring: its bearing on the condition and future of the fishery. *Ibidem*, 1916: 39–87.
TOWNSEND, LAWRENCE D.
1936 Variations in the meristic characters of flounders from the northeastern Pacific. *Rept. Intern. Fish. Comm.*, 11: 1–24.

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The Growth of the Large Mouthed Black Bass, *Huro salmoides* (Lacépède), in the Waters of Wisconsin[1]

By George W. Bennett

A GREAT deal of careful research has been published, during the last ten years, dealing with growth studies of fish. Nearly all of these studies have been based upon material collected either by the scientific worker and his staff (using nets) or upon material obtained by the scientist from the catches of commercial fishermen. These publications cover a large number of species, both among those considered of economic importance as food fish and those of lesser direct economic importance, often classified as rough fish and minnows. However, a brief survey of these publications brings to light the fact that the fish of greatest importance to the fishing public, namely those classified as the more important game species, have been partially neglected. The reason for this is obvious. Game laws restrict these species from the catches of commercial fishermen in nearly all of our inland lakes. Although the scientist is less restricted in his activities, he feels that to kill a large number of important game fish in lakes frequented by fishermen would arouse adverse public opinion, perhaps to the extent that his own activities might be curtailed. As long as the game fish rank first in importance to the public, they should in no way be neglected, although the worker must resort to new methods of obtaining the desired data.

With the purpose of obtaining materials for gamefish growth studies, the Wisconsin Conservation Department, the U. S. Bureau of Fisheries, and the Wisconsin Geological and Natural History Survey (in 1928) requested anglers to cooperate with them by sending in scales from their catches, along with accurate measurements of lengths and weights, determinations of sex, and the lake from which the fish were taken. As soon as this request became widely known, the cooperation was hearty and to date a large amount of data has been collected, not only from the five most important game fish species, i.e., *Esox masquinongy, E. lucius, Stizostedion vitreum, Huro salmoides* and *Micropterus dolomieu,* but also much material from some of the less important species, namely, the bluegill, rock bass, white bass, and trouts.

Since this type of collecting has been in progress, four general reports have been published (mimeographed) (Juday and Schneberger, 1930 and 1933, Juday and Bennett, 1935, Juday and Schloemer, 1936). At the present time, enough materials are available for more detailed reports upon individual species. The first of these, dealing with the growth of the muskellunge in Wisconsin, is already published (Schloemer, 1936).

The recent trend in fisheries biology research is toward fish management,

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i.e., ecological studies of fish and the lakes they inhabit with the object of determining the special requirements of each species, leading eventually to artificial methods of lake improvement, coupled with a sound stocking policy. The value of the scale method as applied to the above cannot be overemphasized, as it gives a definite answer to the question of whether or not a body of water is producing rapid or slow growing fish. The results of scale studies assume the position of the final summation of a complex biological problem from which it is necessary to work backward, in order to determine the values of the other factors involved.

Since 1928 data have been collected from 684 large mouthed black bass, taken from Wisconsin waters. Of this number, data from 46 fish (7.21%) had to be discarded, either because the scales were all regenerated, or were considered unreadable. Scales from 104 of the 684 bass used in this study, were collected by the Bureau of Fisheries, the Conservation Department and the Survey, and those from 580 were collected by the fishermen of the state. Because a large number of the fishermen measured only the total length of specimens (in inches), all calculated lengths represent total, rather than standard lengths.

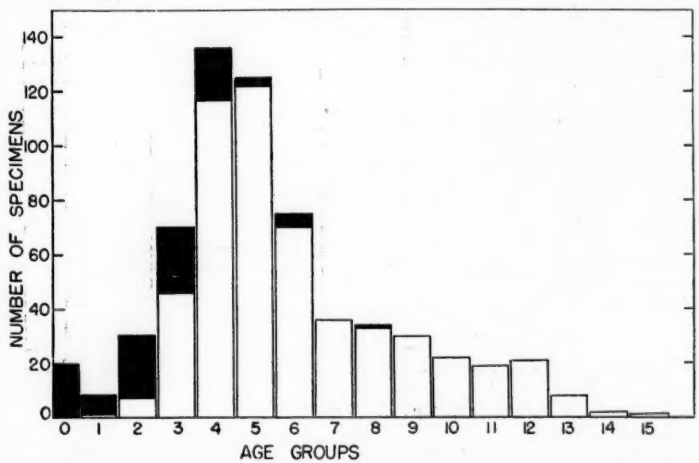

Fig. 1. Frequency distribution of 638 large mouthed black bass grouped into age groups. The darkened areas represent collections made by the Survey, the light represent fishermen's collections.

Distribution of Age Groups

The histogram given in Figure 1 shows the distribution of 638 specimens of the large mouthed black bass (20 specimens in the O age group included), when arranged according to age groups. The fourth group contains the greatest total number (136: combined staff and fishermen's data), while the fifth group represents the greatest number caught by fishermen. The age groups three to ten inclusive, contained a large percentage of the fish caught by fishermen (89%). Age groups O to IV inclusive contained 91% of all collections made by the Survey, filling in the data for the smaller sizes.

The oldest specimen represented in the collection was in its 15th summer when captured. The longest specimen was the heaviest, having attained a length of 26.8 inches and a weight of 7.6 pounds. Seven other bass in the Wisconsin collection exceeded the weight of six pounds. The most rapidly growing fish was taken by the U. S. Forest Service from Rice Creek, Price County, Section 25, T. 40 N., R. 3 E., at the beginning of its 5th summer. This fish weighed 4 pounds, showing an average weight increase of nearly a pound per year.

Rate of Growth

The average rate of growth of 618 large mouthed black bass (20 specimens belonging to group O not included) is shown in the upper curve of Figure 2. The annual increase in length is represented by the increment curve

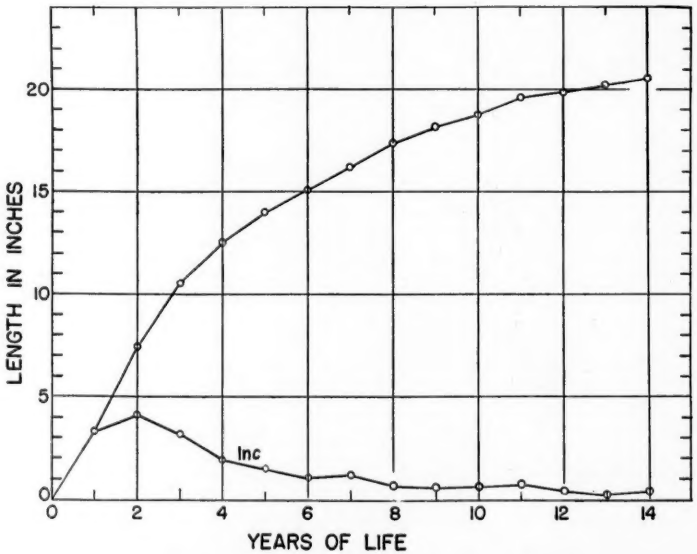

Fig. 2. Growth and increment curves of 618 large mouthed black bass.

in this figure. The curve rises somewhat more strongly the second year than the first, falling off slightly the third year and more strongly during the years following. During the early years, the length increases more rapidly than the weight, but later the weight increases more rapidly in proportion to the increase in length.

The calculated total lengths in inches by years presented in Table 1 show that the average length of the large mouthed black bass for the entire state of Wisconsin for the first year is 3.3 inches; for the second year 7.4 inches; for the third 10.5 inches. These calculations show that this fish reaches a legal length of 10 inches sometime during the third summer. It is probable that spawning takes place for the first time during the third summer, among

TABLE 1. CALCULATED TOTAL LENGTHS ATTAINED BY VARIOUS GROUPS OF LARGE MOUTHED BLACK BASS AT THE END OF EACH YEAR OF LIFE AND THE NUMBER OF INDIVIDUALS COMPRISING EACH AGE GROUP.

Age Group	Average Total Length	No. Specimens	Average calculated total length in inches at end of each stated year of life														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
XV	21.0	1	2.9	6.0	11.4	15.1	16.2	17.2	17.7	18.1	18.5	18.8	19.2	19.6	19.9	20.1	21.0
XIV	21.0	2	3.3	5.2	8.2	9.6	12.2	13.8	15.3	16.6	17.6	18.5	18.9	19.4	19.9	20.8	
XIII	20.5	8	2.8	7.0	10.5	12.3	14.5	15.7	16.6	17.5	18.2	18.8	19.4	19.9	20.3		
XII	20.2	21	3.4	7.6	10.8	13.0	14.5	15.7	16.5	17.6	18.3	18.9	19.6	20.1			
XI	19.8	19	3.6	7.9	11.0	13.2	14.7	15.9	17.0	17.8	18.5	19.1	19.6				
X	18.6	22	3.4	7.2	10.0	11.8	13.5	14.9	16.0	16.9	17.7	18.3					
IX	18.3	31	3.5	7.2	10.5	12.7	14.3	15.5	16.5	17.4	18.1						
VIII	17.5	34	3.6	7.7	10.6	12.9	14.4	15.6	16.5	17.3							
VII	15.7	36	3.0	6.9	9.6	11.9	13.4	14.5	15.5								
VI	14.8	75	3.0	7.1	10.1	12.2	13.6	14.6									
V	14.3	126	3.1	7.3	10.6	12.6	14.1										
IV	12.9	135	3.2	7.5	10.7	12.5											
III	11.6	70	3.6	8.1	11.2												
II	7.1	30	3.3	7.0													
I	5.0	8	3.9														
		618															
Average total length			3.3	7.4	10.5	12.5	14.0	15.1	16.3	17.4	18.1	18.7	19.5	19.9	20.2	20.6	21.0
Average increment			3.3	4.1	3.1	2.0	1.5	1.1	1.2	1.1	.7	.6	.8	.4	.3	.4	

individuals varying between the lengths of 8 and 15 inches, so that, with the legal length set at 10 inches, a small percentage are undoubtedly captured before they have an opportunity to spawn at all. However, the competition for spawning locations in most lakes would probably limit the effectiveness of spawning among the smaller males, because they would be forced by the larger members of the species to select inferior spawning locations.

After the fish become sexually mature, i.e., after the third summer, the yearly increase in length rarely exceeds three inches, gradually becoming less, until after the 8th summer the increase in length is often less than an inch per year.

Growth in Northern and Southern Lakes

Hubbs and Cooper (1934) have found that the long-eared sunfish, *Xenotis megalotis,* becomes progressively dwarfed toward the northern part of its range. For this species in Michigan, there seems to be a good correlation between growth and (1) the average number of days in the growing season (from the last killing frost in the spring to the first killing frost in autumn) and (2) the mean temperature for the year. A survey of the distribution of

Table 2. Calculated Total Lengths Attained by Various Age Groups of Large Mouthed Black Bass at the End of Each Year of Life, from 12 Northern Wisconsin Lakes (Located in Vilas, Washburn, Sawyer, Taylor, Oneida and Bayfield Counties) Compared with the Average Calculated Lengths of Bass from 4 Southern Wisconsin Lakes and the Yahara River (Located in Dane, Jefferson and Washington Counties). In Determining these Averages Each Lake Was Considered as a Unit.

Age in years	Average calculated total length in inches at the end of each stated year of life	
	Northern lakes	Southern lakes and Yahara River
1	2.8	3.7
2	6.5	8.7
3	9.7	11.9
4	11.7	13.7
5	13.2	14.9
6	13.9	16.2
7	15.2	17.3
8	16.7	18.3
9	17.7	19.1
10	18.5	19.7
11	19.3	19.7
12	19.1	19.3
13	19.3	20.0

Wisconsin lakes immediately discloses the fact that they can roughly be divided into two groups, northern and southern, separated more or less completely by a belt extending through the center of the state from east to west, within which very few lakes are present. The northern lakes may again, but less definitely, be separated into northeastern and northwestern groups. Although the southern lakes are mostly located toward the eastern part of the state, they are widely scattered.

Wisconsin lakes from which ten or more examples of the large mouthed black bass have been taken were grouped according to their location (north-

ern or southern). In the northern group were included 12 lakes, located in Vilas, Washburn, Sawyer, Taylor, Oneida and Bayfield countries. The southern lakes were four in number, within Dane, Jefferson, and Washington counties. The Yahara River fish were included with the southern lake data because that river is an overflow between the lakes Mendota, Monona, Waubesa and Kegonsa, and the growth of the large mouth here is practically the same as in Lake Mendota.

According to Whitson and Baker (1928) the mean annual temperature for the northern counties from which the lakes were selected was 41°F. The mean annual temperature for the southern counties in which the southern lakes are located was 45–46°F. The length of the growing season (from the last killing frost in the spring to the first killing frost in autumn) in the southern counties exceeds that in the northern counties by 20 to 45 days.

Table 2 shows the average lengths by years of the northern and southern groups of bass, growth in each lake taken as a unit. The difference in the average sizes between the two groups is least during the first year (.9 inches) and greatest at the end of the 6th year (2.3 inches). Beyond the 8th year the number of specimens becomes so small as to have little significance.

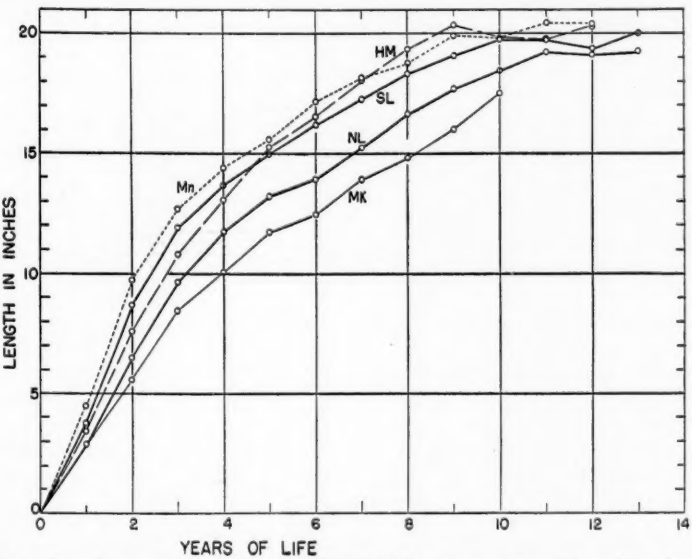

Fig. 3. Growth curves of the large mouthed black bass in northern and southern lakes. HM represents growth in Half Moon lake. MK in Muskellunge; MN in Mendota; NL in northern lakes combined; SL in southern lakes combined.

Figure 3 is a graph showing the growth of the bass in the northern and southern groups of lakes. Included in this graph are curves representing bass growth in Lake Mendota in Dane County, and Half Moon Lake in Oneida County (northern). Growth of bass in Half Moon seems to exceed that in all the northern lakes from the first to the 4th years. In the 5th year the growth

rises above that for all southern lakes and beyond the 7th year it even exceeds Mendota, one of the better lakes of the southern group. However, the sample from Half Moon Lake is too small (13 specimens) to draw any definite conclusions.

The difference in growth rates between these northern and southern lakes cannot be attributed entirely to a difference in temperature or to the length of the growing season. Hardness of the water may be a factor equally as important. Hile (1936) states: "In general, the bound CO_2 in a lake's waters is roughly indicative of the biological productive capacity of that lake." His studies show that the ciscoes made poorest growth in lakes having the greatest concentration of bound CO_2. However, the populations were also greater in these lakes.

While a good many of the northern lakes are known to be "soft water" lakes, some of them are comparatively hard. The water of all of the southern lakes is hard.

Growth Rates in Lake Mendota

In studying the scales of the larger bass taken from the waters of Wisconsin, it became apparent that the largest fish were usually not the oldest, and that the growth rates of these larger individuals were greater throughout

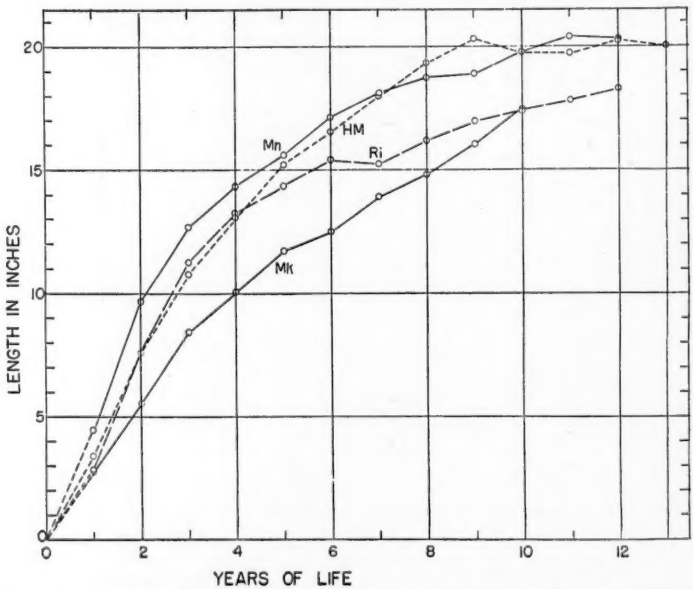

Fig. 4. Average growth rate curves for Groups I and II plotted with the growth curve for Lake Mendota (see text).

their life spans than in the average fish. Lee's phenomenon of apparent decrease in the calculated growth as it is determined from successively older groups of individuals was found in general not to apply to the large mouth.

In order to determine if possible whether races of rapidly growing bass were present in Lake Mendota, all fish weighing more than four pounds were selected from the 99 specimens taken from this lake for study. These were 15 in number (15.2%). When arranged by age groups they were found to include groups VII–XII. These age groups were taken as the limits of this study. Following, all fish weighing less than four pounds, but belonging to these same age groups were added to the selected collection. Considering the age groups from VII–XII as a unit, a distribution curve was constructed, by arranging according to weight, the specimens coming within this range. In order to study the growth rates of the individuals at the extreme ends of the curve, arbitrary limits were set above and below the mode, located between the weights of 4 and 4.9 pounds inclusive. All fish above 4.9 pounds in weight were taken as Group I and all fish below 4 pounds as Group II. The age groups represented in Group I were: VIII (1), XI (3), XII (1); total 5 specimens; those in Group II age groups: VII (3), VIII (2), IX (2), X (1), XII (2); total 10 specimens. The average growth rates of Group I and II were plotted as shown in Figure 4, along with the curve of the average growth rate of all fish from Mendota. The data are given in Table 3. From a survey

TABLE 3. CALCULATED TOTAL LENGTHS OF THE LARGE MOUTHED BLACK BASS FROM LAKE MENDOTA AT THE END OF EACH YEAR OF LIFE. GROUP I REPRESENTS THE AVERAGE GROWTH RATE OF ALL FISH WEIGHING 5 OR MORE POUNDS, BELONGING TO AGE GROUPS VII–XII; GROUP II REPRESENTS THE AVERAGE GROWTH RATE OF ALL FISH WEIGHING LESS THAN 4 POUNDS BELONGING TO THESE SAME AGE GROUPS. GROUPS I AND II ARE LISTED TOGETHER WITH THE AVERAGE GROWTH RATE FOR ALL AGE GROUPS FROM MENDOTA.

Age in years	Average calculated total length in inches at end of each stated year of life		
	Group I 5 specimens	Group II 10 specimens	Average 99 specimens
1	4.9	3.7	4.5
2	10.5	8.7	9.7
3	13.9	12.0	12.6
4	16.0	14.1	14.4
5	17.3	15.5	15.6
6	18.5	16.3	17.2
7	19.5	17.6	18.1
8	20.3	18.3	18.8
9	20.5	18.6	18.9
10	20.9	19.4	19.8
11	21.4	20.1	20.4

of the table it seems that in Lake Mendota the larger fish show a more rapid growth rate, resulting in a size that is never attained by the slow growing fish. This may be due to a difference in the growth rate of the sexes (sex data not complete from Mendota fish) although two fish belonging to Group I were sexed as follows:

Male; 5¼ pounds; 22.3 inches; age XI.
Female; 5½ pounds; 22.2 inches; age XI.

In Group II the only fish for which the sex was given were:

Female; 3.6 pounds; 18 inches; age VIII.
Female; 3.3 pounds; 19.3 inches; age X.

From the above it is possible to infer the presence of rapidly growing races of fish in Lake Mendota, or a differential growth rate between sexes for the large mouthed black bass. According to Hubbs and Cooper (1935) in the genera *Xenotis* and *Apomotis* of the Centrachids, the male grows faster than the female. This statement is substantiated by Creaser (1928) for *Eupomotis gibbosus,* Tester (1932) for *Micropterus dolomieu,* and Hubbs and Hubbs (1933) for *Eupomotis gibbosus, Helioperca incisor* and hybrids.

It may be possible that large individuals represent fish that became predatory very early in life. Langlois (1936) speaks of young small mouth reared in ponds as follows: "Predaceous individuals outgrow their fellows, and the variations of length have been found to indicate the type of social organization which prevails in a pond when it is drained." However, if this early rapid growth rate continues throughout the life of the individual fish inhabiting a lake with a mixed population, one can possibly assume that continued rapid growth may be due to factors other than cannibalism. Hubbs and Cooper (1934) state: "The positive correlation between the growth (in sunfishes) of the first and the second year at one locality may be due to any of four reasons:

(1) The individuals which attain a greater growth during their first year, owing to early hatching or any other factor, may possess such a competitive advantage over the slowly growing fish of the same age that they obtain more food during the second year.

(2) Some fish select and inhabit through both years niches particularly conducive to rapid growth, or the reverse.

(3) The rate of growth in the first year may in some physiological way similarly affect the growth of the second year.

(4) There may be genetic differences in growth potential between different individuals."

The first possibility would hardly apply to the large mouth over a period longer than two years, in lakes having a mixed population of fish of all sizes. It is also hardly possible that a bass could inhabit for a great length of time a single ecological niche, due to the frequent changes in food and habits. Points (3) and (4) might in part explain the unequal growth rates of the two groups.

While the absence of parasites might not account for the rapidity of growth of the bass in Group I, the presence of parasites in a large percentage of the bass population of Lake Mendota, might affect the growth in that population, so that the average growth rate is actually below what might be considered "normal" (potential growth rate). Hubbs (1927) has shown that in the minnow, *Platyogobio gracilis,* heavily parasitized specimens infested during their first year were on the average shorter than their non-parasitized companions of the same age. He was unable to show any differences between normal and heavily infested fish after the first year. Cross (1937) has found that heavily parasitized fish are retarded in growth. "This retardation in growth seems to be greater when the weight of the fish is considered, than when the length alone is used as a measure of growth." Although no figures are given for the percentage of parasitized large mouth, Cross found that from

TABLE 4. CALCULATED TOTAL LENGTHS ATTAINED BY THE LARGE MOUTHED BLACK BASS AT THE END OF EACH YEAR OF LIFE GIVING AVERAGE GROWTH RATES FOR LAKES FROM WHICH 10 OR MORE SPECIMENS WERE TAKEN.

Lake	County	No. Spec.	Average calculated total length in inches at end of each stated year of life												
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Anderson	Taylor	10	2.7	7.4	10.7	13.0	13.9	13.6	....	....	....	....	....	....	....	....
Big Bass	Vilas	21	3.0	6.2	9.1	11.4	12.9	14.3	15.4	16.9	18.1	19.2	19.6	....	....	....
Bear	Vilas	15	2.7	6.9	10.3	12.5	12.6	14.0	15.5	16.6	....	....	....	....	....	....
Black Oak	Vilas	12	3.1	6.0	8.9	10.8	12.7	14.8	15.3	15.9	16.7	16.2	17.1	17.6	18.6	19.1
Delta	Bayfield	10	2.1	6.9	10.7	13.7	15.4	16.1	....	....	....	....	....	....	....	....
Duggan	Washburn	12	2.0	5.1	8.7	11.2	13.4	12.8	14.9	15.6	16.2	....	....	....	....	....
Half Moon	Oneida	13	3.4	7.6	10.8	13.1	15.3	16.5	18.0	19.4	20.3	19.8	19.7	20.3	20.0	....
Ike. Walton	Vilas	21	3.1	6.6	9.5	11.1	12.2	12.6	13.5	....	....	....	....	....	....	....
Larry	Vilas	17	1.7	4.5	6.8	8.7	9.3	....	....	....	....	....	....	....	....	....
Lucas	Washington	13	4.2	9.3	12.6	14.5	16.3	17.4	19.5	20.8	21.4[1]	21.9	20.9	....	....	....
Mendota	Dane	99	4.5	9.7	12.7	14.4	15.6	17.2	18.1	18.8	18.9	19.8	20.4	20.4	....	....
Little Star	Vilas	14	3.5	7.2	10.7	12.4[1]	13.5	12.2	....	....	....	....	....	....	....	....
Muskellunge	Vilas	39	2.8	5.6	8.4	10.1	11.7	12.5	13.9	14.8	16.1	17.5	....	....	....	....
Ripley	Jefferson	20	2.9	7.7	11.3	13.3	14.3	15.4	15.3	16.2	16.9	17.4	17.9	18.3	20.0	....
Teal	Sawyer	16	3.1	7.1	9.9	11.8	13.4	14.7	15.9	16.9	17.5	18.1	18.9	19.1	18.1	....
Waterloo	Jefferson	51	2.4	6.8	10.1	12.3	13.5	14.6	16.2	17.5	....	....	....	....	....	....
Yahara River	Dane	10	4.7	9.8	12.8	14.1	15.1	16.4	....	....	....	....	....	....	....	....

76 to 100% of the small mouthed bass from Nebish, Muskellunge, and Silver lakes in Vilas County were infested with trematode cysts; "adult cestodes, *Proteocephalus ambloplites* were common in the intestine;" "Acanthocephala were very common in the small mouth and were often found in very large numbers." Pearse (1924) states that in all Wisconsin lakes studied, the small mouth bass always contained more parasites than the large mouth. In Lake Mendota the large mouth were infested with *Diplostomum* sp. (Trematoda), *Proteocephalus ambloplites* (Cestoda), *Ichthyonema cylindraceum* (Nematoda), *Neoechinorhynchus cylindratus* (Acanthocephala), and *Piscicola punctata* (Hirudinea). The degree of parasitic infestation in the large mouth of Lake Mendota is unknown. Whether or not the rapidly growing specimens in this lake represent individuals having relatively few parasites cannot be determined at this time. It is possible that extremely rapid growth may be dependent upon a number of factors working together, i.e., a light parasitic infestation, coupled with early hatching, and a high growth potential, etc.

Comparative Rates of Growth in Individual Lakes

The large mouth data include material from 123 lakes, although the number of specimens from most of these lakes is small. It is generally agreed that at least 150 specimens of all sizes should be collected from a single lake,

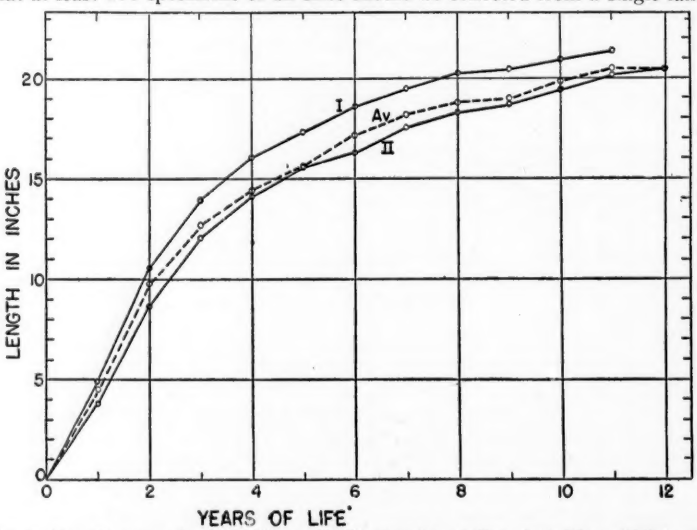

Fig. 5. Growth curves for Muskellunge (MK), Mendota (MN), Half Moon (HM), and Ripley (RI) Lakes.

in order to have an adequate sample of a single species from that lake. However, considerably smaller samples may be considered indicative of fish growth. In this study all lakes from which 10 or more samples have been taken are used. Thus the ultimate values of the averages for growth in the various lakes depend directly upon the number of specimens in each study.

Table 4 gives the calculated total length in inches by years of life for lakes from which 10 or more specimens have been taken. It will be noted

that in some lakes the bass grow slowly at first, but in later years the growth becomes more rapid, so that the fishes from certain lakes may eventually exceed those inhabiting other lakes in which the growth is rapid at first but retarded later. In comparing Lucas Lake bass with those of Mendota, it is found that growth in Lake Mendota is slightly faster for the first three years, but that during the 4th year Lucas Lake bass exceed those from the former lake in length. This lead is held then throughout the following years.

Of all lakes listed, Larry Lake in Vilas County shows the poorest growth rate for the large mouth. According to the Survey reports, this lake is greatly overpopulated. Half Moon Lake in Oneida County is probably the best bass producing lake in northern Wisconsin, at least from the standpoint of rapid growth rate. In the southern part of the state the large mouth grows most rapidly in Mendota and Lucas lakes. Waterloo Lake in Jefferson County, although practically dry at the present time, once produced bass having a good rate of growth.

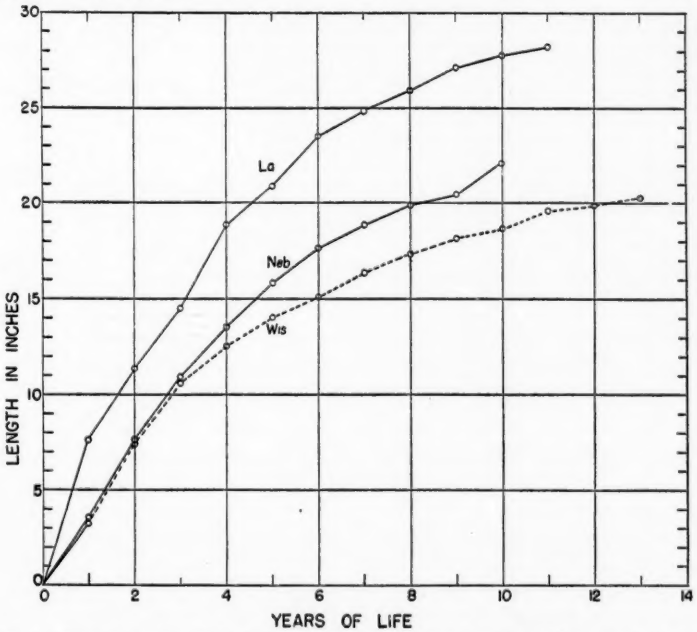

Fig. 6. Growth curves of 30 large mouthed black bass from Louisiana, and 25 from Nebraska, compared with that of 618 bass from Wisconsin.

Figure 5 shows the curves of growth of four lakes plotted together: Mendota, Half Moon, Ripley and Muskellunge. Muskellunge large mouth seem to grow rather slowly as compared with those of Mendota, Half Moon and Ripley, which show good growth rates. During the years following the 5th, however, growth in Ripley falls definitely below that in Mendota and Half Moon.

Comparative Growth of the Large Mouthed Black Bass in Wisconsin, Nebraska and Louisiana

Data from 30 specimens of the large mouth, collected by Mr. Percy Viosca, Jr., from Louisiana and from 25 large mouth from collections made by fishermen in Nebraska are included in Figure 6, along with the curve representing the growth of 618 fish from Wisconsin. Table 5 lists the calculated total lengths in inches for each year. At the end of the first year of life the southern fish average nearly twice as long as either the Nebraska or Wisconsin bass. The greatest yearly increase in length in both Wisconsin and Nebraska bass takes place during the second summer. In the Louisiana bass the greatest increase in length takes place during the first summer, although there is a second high during the 4th summer (4.3 inches).

Table 5. Calculated Average Total Lengths of the Large Mouthed Black Bass from Wisconsin, Compared with Small Samples from Louisiana and Nebraska.

Age in years	Average calculated total length in inches at end of stated year of life		
	Wisconsin 618 specimens	Louisiana 30 specimens	Nebraska 25 specimens
1	3.3	7.6	3.6
2	7.4	11.3	7.6
3	10.5	14.5	10.9
4	12.5	18.8	13.5
5	14.0	20.9	15.8
6	15.1	23.5	17.6
7	16.3	24.8	18.9
8	17.4	25.9	19.8
9	18.1	27.1	20.4
10	18.7	27.8	22.1
11	19.5	28.3	...
12	19.9	...	...
13	20.2	...	...
14	20.6	...	...
15	21.0	...	...

Neither of the growth curves from Louisiana or Nebraska fish represent more than a slight sample from either state. The Nebraska curve is probably less representative of that state than the curve for Louisiana, as about 50% of the fish included were taken from sandpit lakes, notoriously poor fish producing waters.

Although little significance can be attached to the small samples from Louisiana and Nebraska, this comparison suggests need for a broader viewpoint in the study of growth of any given species of fish, leading to a greater understanding of the effect of temperature and the length of the growing season upon fish growth.

The growing season in Louisiana lasts probably at least 9 months; that in Nebraska, 5–6 months; and Wisconsin, 4–5 months.

Summary

1. This study is based on the age determinations of 684 large mouthed black bass from Wisconsin, by means of the standard scale methods.

2. The average large mouth reaches legal length (10 inches) in Wisconsin during the third summer of life. Of the fish taken by fishermen 89% were included within age groups III to X, and the greatest yearly returns were from age group V.

3. The oldest specimen was in its 15th year when captured. The largest specimen (age group X) was 26.8 inches in length and weighed 7.6 pounds. The most rapidly growing specimen averaged a weight increase of nearly a pound per year for the first 5 years.

4. Owing to a longer growing season, or to a difference in the character of the lakes, the large mouth grows more rapidly in the southern part of the state, than in the north.

5. The bass from Lake Mendota show a differential growth rate, due to a difference in the growth rate of sexes, to parasitism, or to other factors.

6. The growth of the large mouth is most rapid in Mendota, Lucas and Half Moon lakes. The poorest growth was made in Muskellunge and Larry lakes.

7. A comparison of the growth rates of the large mouth from Wisconsin, Nebraska, and Louisiana suggests the importance of temperature and length of the growing season in relation to growth rate.

Literature Cited

Creaser, C. W.

1926 The structure and growth of the scales of fishes in relation to the interpretation of their life-history, with special reference to the sunfish, *Eupomotis gibbosus*. *Misc. Pub. Mus. Zool., Uni. Mich.* 17: 1–82, figs. 1–12, pl. 1.

Cross, S. X.

1937 A study of the fish parasite relationships in the Trout Lake region of Wisconsin. *Wisc. Acad. Sci. Arts and Letters,* 31: in press.

Hile, R.

1936 Age and growth of cisco, *Leucichthys artedi* (Le Sueur), in the lakes of the northeastern highlands, Wisconsin. *Bureau of Fish.,* 48 (19).

Hubbs, C. L.

1927 The related effect of a parasite on a fish. *Jour. of Parasit.,* 14: 75–84.

Hubbs, C. L. and G. P. Cooper

1934 Age and growth of the long-eared and green sunfishes in Michigan. *Pap. Mich. Acad. Sci., Arts and Letts.,* 20: 669–696, maps 46–47, figs. 57–60, pls. 104–108.

Hubbs, C. L. and Laura C. Hubbs

1933 The increased growth, predominant maleness, and apparent infertility of hybrid sunfishes. *Ibidem,* 17, 1932: 613–641, figs. 69–71, pls. 64–65.

Juday, Chancey and G. W. Bennett

1935 Growth of gamefish in Wisconsin waters. Third report. *Notes from the Limnological Lab. of the Wis. Geol. and Nat. Hist. Serv.,* May: 1–13 (mimeographed).

Juday, Chancey and Clarence Schloemer

1936 Growth of game fish in Wisconsin waters. Fourth report. *Ibidem,* June: 1–17, Figs. 1–4 (mimeographed).

Juday, Chancey and Edward Schneberger

1930 Growth studies of game fish in Wisconsin lakes. *Notes from the Biol. Lab. of the Wis. Geol. and Nat. Hist. Surv.,* March: 1–7 (mimeographed).

1933 Growth studies of game fish in Wisconsin waters. Second Report. *Notes from the Limnological Lab. of the Wis. Geol. and Nat. Hist. Surv.,* April: 1–10, figs. 1–2 (mimeographed).

LANGLOIS, T. H.
1936 A study of the small mouth bass, *Micropterus dolomieu* (Lac.) in rearing ponds in Ohio. *Ohio Biol. Surv.*, Bull. 33, 6 (4), Oct.
PEARSE, A. S.
1924 The parasites of lake fishes. *Trans. Wisc. Acad. Sci. Arts and Lett.*, 21: 147–160.
SCHLOEMER, C. L.
1936 The growth of the muskellunge, *Esox masquinongy immaculatus* (Garrard), in various lakes and drainage areas of northern Wisconsin. COPEIA, 1936, Dec. 31, No. 4: 185–192.
TESTER, ALBERT L.
1932 Rate of growth of the small mouthed black bass (*Micropterus dolomieu*) in some Ontario waters. *Pub. Ont. Fish. Res. Lab.*, 47: 205–221, figs. 1–2, pl. 1.
WHITSON, A. R. AND O. E. BAKER
1928 The climate of Wisconsin and its relation to agriculture. *Agri. Exp. Sta., Uni. of Wisc.*, Bull. 233, May.

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A New Species of *Rhadinaea* from San Luis Potosi

By JOSEPH R. BAILEY[1]

IN the course of an investigation of the snakes of the genus *Rhadinaea*, a distinct and hitherto unrecognized species was discovered among the collections of the Museum of Comparative Zoology at Cambridge. I take pleasure in naming this pretty new species for Mrs. Helen Thompson Gaige, in recognition of her friendship and the many thoughtful kindnesses she has extended to me.

Rhadinaea ***gaigeae,*** new species

TYPE.—M. C. Z. 24983, adult male, Alvarez, San Luis Potosi, Mexico, collected June 9, 1926, by W. W. Brown.

PARATYPES.—M. C. Z. 24892, 24894–95, 19047, same locality and collector as the holotype; 4359, mountains of Alvarez, 16 leagues southeast of San Luis Potosi.

DIAGNOSIS.—A *Rhadinaea* with 17 scale rows throughout; ground color light olive brown with fine black lines through the median and fourth lateral scale rows; a light line, bordering the lateral dark line above, continuous along sides of neck to eye.

DESCRIPTION OF TYPE.—Body attenuate, tail long, head distinct from neck. Dorsals 17–17, ventrals 160, anal divided, subcaudals in 89 pairs. Loreals 1–2 plus a small subpreocular, temporals 1–2. Upper labials 8, 4 and 5 in eye; lower labials 10/11, 6/7 in contact with chin shields. Nasal divided;

[1] Contribution of the Department of Biology, Haverford College, number 38.

loreal squarish; frontal as long as its distance from the tip of the snout, distinctly shorter than parietals; internasal suture about half the length of the prefrontal suture; rostral low and broad, visible from above.

Narrow black lines extend through the median and fourth lateral scale rows. Ground color light olive brown. The lateral dark lines are bordered above by a contrasting light stripe on the fifth row and halves of the adjacent rows. This light stripe is continuous on the sides of the neck through the temporals, outer corner of the parietals and top of the eye, and around the rostral (rather indistinct anterior to eyes). The outer edges of the ventrals, and sides below the lateral dark stripe, are finely dotted with scattered black flecks. The upper labials are yellow, black edged above; those entering the eye and anterior to it, the lower edge of the rostral, the mental and anterior three lower labials, all bear a few small black spots. Otherwise the chin and ventral surface are immaculate yellow (in life?).

Maxillary teeth 14 followed by a gap and two slightly enlarged teeth. The hemipenis is seven subcaudals long, to the muscle. There are several very small hooks proximally, followed by 15 moderate hooks of varying sizes between subcaudals 3–6, then a well defined capitate tip.

Variations in Paratypes.—Color uniform for the whole series. Number 24892 has a hemipenis essentially like that described. Two paratypes have identical maxillary dentition. The labials are identical in number and arrangement, except that all the paratypes have ten lower labials on each side. The subpreoculars may be lacking. Number 19047 has the first pair of lower labials divided transversely, so they are not in contact with each other. The males have tubercles on the dorsal scales of the anal region. Scale and size variation are tabulated below:

No.	Sex	Ventrals	Caudals	Subpre-ocular	Body Length	Tail Length	Tail Body
24983	m.	160	89	yes	328	154	47.0
24982	m.	160	97	no	315	163	51.7
24985	m.	164	...	no	295	...	....
4359	m.	157	110	one side			
24984	f.	167	85	yes	358	151	42.2
19047	f.	163	83[a]	one side	337	144[a]	42.7[a]

[a] Tail probably not quite complete.

Relationships.—The most closely related forms are unquestionably to be found in Mexico, among those currently lumped under the name *vittata*. These are at present in such a state of chaos in respect to the proper allocation of names to recognizable forms, that I leave a discussion of relationships until the nomenclatorial questions can be more definitely settled. *Rhadinaea gaigeae* is so distinct from any *Rhadinaea* I have seen or that has been described, that the diagnosis will serve to distinguish it.

I am indebted to Mr. Arthur Loveridge of the Museum of Comparative Zoology for the privilege of describing these specimens.

Haverford College, Haverford, Pennsylvania.

A Tentative Revision of the Genus *Necturus*[1] With Descriptions of Three New Species from the Southern Gulf Drainage Area

By Percy Viosca, Jr.

I HAVE believed for some time that the waterdogs of Louisiana, not distinguished heretofore from *Necturus maculosus* (Rafinesque), were distinct from that species. Recent ecological studies and a critical examination of specimens from practically the entire area covered by the genus have confirmed the view that this is an undescribed species. While seeking material from the territory east of Louisiana, two additional new forms have come to light, one from the Gulf Coastal Plain near Mobile and one from the southwestern extremity of the Cumberland Plateau near Tuscaloosa. Furthermore, a study of North Carolina specimens has convinced me that Brimley's form *lewisi*, described as a subspecies of *maculosus*,[2] merits full specific rank, raising the number of recognizable species (with *N. punctatus*) from two to six.

A number of the characters heretofore ascribed to *Necturus maculosus* (Rafinesque) are unquestionably of generic significance only. The descriptions and key which follow define the genus and six species in the light of these investigations, and offer new characters for their discrimination. As the condition of the specimens in museums varies considerably, great caution had to be used in defining characters—hence the tentative nature of some of the descriptions and the omission of apparently good characters which cannot as yet be well defined. Statistical analyses of racial trends and more accurate definitions of the species cannot be expected until larger series from the various river systems are accumulated. So that body proportions can be determined more accurately, representatives of these populations should be similarly preserved when freshly collected, preferably by injection after chloretone narcotization and without pressure.

I am deeply indebted to George H. Penn, Jr. for valuable assistance rendered in the statistical study of the specimens, preparation of the tables, and recent field investigations; and to Henry B. Chase, Jr., my co-worker in field investigations. The new species from Louisiana is named for the pioneer student of Louisiana herpetology, the late George E. Beyer (1861–1926). The species from southern Alabama is named for H. P. Löding of Mobile, pioneer student of Alabama reptiles and amphibians, through whose efforts have come to light the types upon which this species is based. I am indebted to J. Henry Walker, Jr. for the type of the new species from the Black Warrior River near Tuscaloosa, Alabama, and to Septima Smith and Walter B. Jones for an assortment of specimens from the same vicinity.

I am indebted to Leonhard Stejneger and Doris M. Cochran for the loan of specimens from the National Museum collections and for examination of the type of *N. lewisi;* to C. S. Brimley for the loan of specimens, and for

[1] A contribution from the Research Dept., Southern Biological Supply Co., Inc., New Orleans, La.

[2] Brimley, C. S. The waterdogs (*Necturus*) of North Carolina. *Jour. Elisha Mitchell Scien. Soc.*, XL, Nos. 3 and 4, 1924.

valuable information regarding the North Carolina species; to North Carolina State Museum, and the Washington (N.C.) Field Museum for the loan of North Carolina specimens; to Helen T. Gaige for specimens from the University of Michigan Museum of Zoology; to Thomas Barbour and Arthur Loveridge for specimens from the Museum of Comparative Zoology; to A. O. Weese for specimens from the University of Oklahoma collections; to M. Graham Netting for specimens from the Carnegie Museum, one a paratype of Brimley's *lewisi;* to E. B. Powers and Barton C. V. Ressler for specimens from eastern Tennessee; to C. S. Shockley for specimens from the Wabash River; to Malcolm V. Parker for specimens from the central Mississippi Basin; and to many others who have submitted information needed in this study.

NECTURUS (Rafinesque)

Tail present throughout life, greatly compressed, with a wide dermal border; external gills, 3 on each side, persistent throughout life; 4 legs, approximately equally developed, four toes on each; a mid-dorsal and normally 14 (13 to 15) costal grooves; head wider than deep, ovoid; a gular fold; eyes small, eyelids absent; nostrils small, near edge of lip; tongue rounded, somewhat free anteriorly.

Figure 1. *Necturus alabamensis* sp. nov., the type, a mature female, natural size.

Necturus ***alabamensis,*** sp. nov.

TYPE.—U.S.N.M. No. 102676, a gravid female collected in Black Warrior River near Tuscaloosa, Alabama, Jan. 22, 1914 (fig. 1). Total length

168 mm.; head[3] 30 mm. (in length 5.60); tail 58 mm. (in length 2.89); width of head 20 mm.; depth of head 11.5 mm. (in width of head 1.74); width of body 17 mm.; depth of body 12 mm. (in width of body 1.42); costal grooves 14. Head and body depressed; muzzle rounded in outline, flattened in profile; canthus raised; origin of upper dermal border of tail behind vent. Tooth formula: premaxillary, right 9, left 11; vomero-palatine, right 9, left 6; pterygoid, right 5, left 6.

Color, in formalin: on dorsal region of head and body, a brown reticular mottling enclosing rounded and irregular lighter spots, the whole superimposed with dark rounded spots, these tending to form three irregular longitudinal rows on the back; sides darker, the brown color separating isolated rounded light spots, this pattern superimposed with a row of dark spots, much larger than the dorsal spots, in the dorso-lateral region (7 on right and 8 on left); underparts immaculate except on sides, chin, and tail, the lateral pattern encroaching on the venter to form conspicuous edges marked with superimposed dark spots, these not larger than the dorsal spots. The total number of dark spots is about 104 in about 7 rows. A dark line extends along canthus through eye to gills.

Summary of Diagnostic Characters.—In addition to the type, only one specimen, poorly preserved and without data, is available. This was found in the Zoology Department, University of Alabama, and is apparently from the vicinity. J. Henry Walker informs me that he has seen two other specimens, similar in appearance to the type, from the same locality, and residents of the type locality recognize the species from my photographs. Size apparently small, average weight of the two specimens, in formalin, 24.3 grams (approx. 4/5 oz.); head and body apparently depressed as in *maculosus;* head angular, muzzle rounded, not truncated. Ground pattern: dorsally a brown reticular mottling enclosing irregular light spots; laterally a pattern of scattered light spots on a brown ground extending onto the sides of the venter where it terminates sharply; underparts immaculate centrally except on chin and tail. Dark spots near 100; about 3 irregular rows on back; one fairly regular, dorso-lateral row on either side, these much larger than either the dorsal or the latero-ventral series, 7 to 8 between the axilla and groin; one latero-ventral row on either side of the immaculate midventral region. Tooth formula: 9 (8–11), 9 (6–10), 5.5 (5–6).

Life History Data.—Judging by the fully mature condition of the two available specimens and from statements made to me by residents of the type locality which I visited in January, 1937, this may be a relatively small species. The gravid condition of the type, which was taken during the month of January, and the fact that they are reported in the river only in the early months of the year would indicate an early spring spawning season. The relatively depressed body is suggestive of a rocky stream habitat.

[3] The head is measured from the tip of the muzzle to the line connecting the inner bases of the upper gill insertions; the tail, from the middle of the cloaca to the tip, including the dermal border; the width of the body, at the widest point in the first third (near the fourth or fifth costal groove); the depth of the body, at the same point as the width.

Necturus ***beyeri,*** sp. nov.

TYPE.—U.S.N.M. No. 102674, a female, collected in the Upper Calcasieu River near Oakdale, Louisiana, winter of 1928 (fig. 2). Total length 209 mm.; head 35 mm. (in length 6.00); tail 70 mm. (in length 2.99); width of head 26 mm.; depth of head 18 mm. (in width of head 1.44); width of body 21 mm.; depth of body 19 mm. (in width of body 1.10); costal

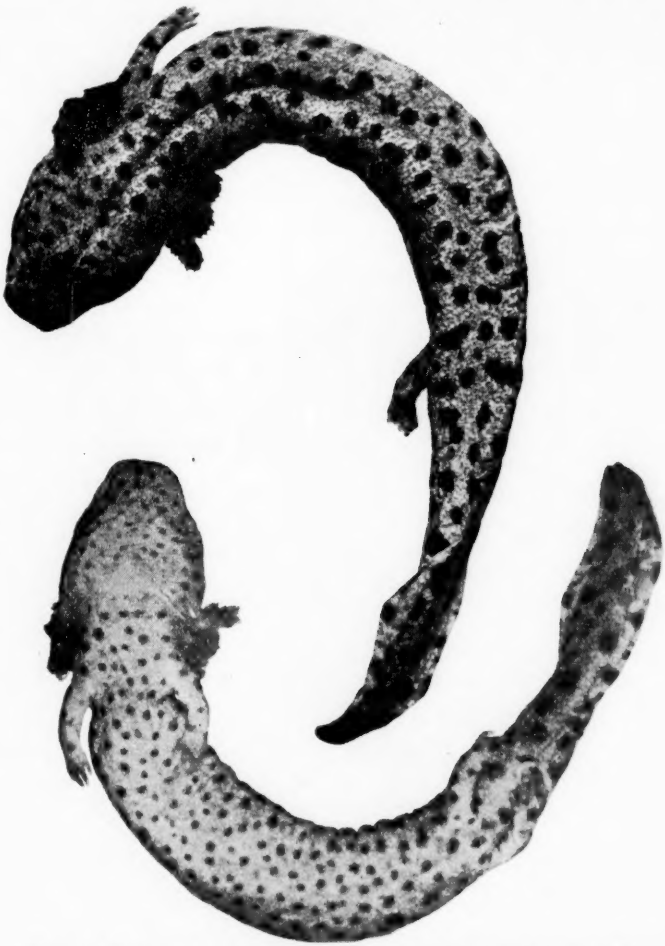


Figure 2. *Necturus beyeri,* sp. nov., the type, a mature female, natural size.

grooves 14. Head and body sub-cylindric; muzzle beak-like, truncate in outline, "hog-nosed" in profile; origin of upper dermal border of tail above anterior border of vent. Tooth formula: premaxillary, right 10, left 9; vomero-palatine, right 10, left 11; pterygoid, right 6, left 6.

Color, in formalin: above and on sides a brown reticular mottling enclosing roundish and irregular areas of a whitish ground color, the whole superimposed with numerous roundish dark brown spots; below and on throat the brown pigmentation is less intense, the mesh of the reticulation is smaller, often reducing the light spots to mere dots, and the superimposed dark spots are much reduced in size. The total number of dark spots on the entire animal is a little over 200, in about 14 rows; the lateral spots are similar to the dorsal spots, forming about 3 irregular rows on each side, the number between the axilla and groin about 30. Canthus and eye mottled with dark brown, the pigmentation tending to but not forming a distinct dark line.

PARATYPES.—An excellent series of adults (6 males and 14 females) was obtained from the Calcasieu River near Oakdale, Louisiana. The type and a paratype from the same stream, U.S.N.M. No. 102676, have been presented to the U.S. National Museum. Specimens M.C.Z. 17732 and 17733 from the same lot are the property of the Museum of Comparative Zoology at Cambridge. The remaining paratypes are in the author's herpetological collections. Only the Calcasieu River series was included in the statistical analysis (Table I).

Other specimens assigned to this species are: 4 specimens, 1 female, 1 immature male, and 2 juveniles, from streams near Covington, Louisiana: nine larvae and four juveniles from the headwater creek of Bayou Lacombe north of Lacombe, Louisiana; 1 mature female from Brookhaven, Mississippi; U.S.N.M. No. 13390, 2 specimens, from Montgomery, Alabama; 1 specimen from Hall's Mill Creek near Mobile, Alabama; 1 specimen from a pond at Tuscaloosa; and 3 specimens without data from the Zoology Museum at Tuscaloosa. A specimen from the Tangipahoa River was seen at Hammond, Louisiana, and two from the Pearl River, at Columbia, Mississippi.

SUMMARY OF DIAGNOSTIC CHARACTERS.—(based on the Calcasieu series). Size medium, adults 160 mm. to 223 mm., ave. 203 mm.; weight in formalin, ave. 36.4 grams (approx. 1.3 oz.). Head and body sub-cylindric; muzzle truncate, beak-like. Ground pattern: above a brownish reticular mottling enclosing roundish and irregular light spots; more definitely reticular laterally; below a paler brown separating isolated light spots, or sometimes immaculate; tail with light spots on a darker ground. Dark spots usually over 200, ave. 265; lateral, dorsal, and tail spots similar in size; head and ventral spots smaller, rarely absent below; 17 to 53 lateral spots in 3 or 4 irregular longitudinal rows between axilla and groin. Tooth formula: 9 (7–12), 10 (9–12), 6.5 (5–8).

LIFE HISTORY DATA.—The life history of this species will be dealt with in a separate paper.

Necturus lewisi (Brimley)

TYPE.—U.S.N.M. No. 6868, Neuse River, near Raleigh, North Carolina, not seen by author.

SERIES EXAMINED.—Brimley's paratypes are included in the series examined. A total of 27 specimens were studied, all from North Carolina. Twenty-two were from the Neuse River system, and 5 from the Tar River system. Of these, 11 were juveniles and 4 larvae.

SUMMARY OF DIAGNOSTIC CHARACTERS.—Size medium, adults 168 mm. to 276 mm., ave. 202 mm., weight in formalin, ave. 44.4 grams (approx. 1.5 oz.). Head and body sub-cylindric; muzzle probe-like (fig. 3). Ground pattern (in formalin) consisting of fine purplish brown vermiculate mottlings and irregular whitish spots above and coarse reticulations of the same color enclosing whitish spots on sides and belly; the whole superimposed with less than 100 rounded dark spots of eggplant purple. Lateral spots, 5 to 15 between axilla and groin, about 5 to 8 in a dorso-lateral series, the largest of these about twice the size of the largest dorsal spots, but sometimes partly obscured, especially in old adults, by additional spots and reticulations. Ventral spots and reticulations always extend to mid-ventral line. Tooth formula: 11 (10–14), 11 (9–12), 5.7 (5–7).

Figure 3. *Necturus lewisi* (Brimley). Left, young male from Raleigh, N.C.; right, large male from Washington, N.C.; both natural size.

LIFE HISTORY DATA.—In 55 mm. larvae of this species, the entire dorsal region (in formalin) is a light grayish brown with a few ill-defined dark spots and vermiculations; this area broadens on the head, and in the rear it terminates at the origin of the upper dermal border of the tail. The sides are dark

brown with more or less elongated light spots tending to be arranged in longitudinal rows. A faint darker band extends backward from the gills in a groove. A more or less irregular dark line extends along the canthus and through the eye to the anterior border of the gills. The tail is dark with scattered light spots, a light or spotted upper dermal border, and a light lower dermal border. The lower parts are light with occasional pigment spots, especially along the costal grooves, near the hind legs, and bordering the lower jaw.

The ill-defined, dark dorsal spots of the juvenile which occupy the light dorsal area become more prominent with age and are already well defined at 90 mm. The faint dorso-lateral band shows areas of greater pigmentation at an early age (55 mm.). These transform into the large lateral spots which are already fairly well defined at 90 mm. Smaller spots in the ventro-lateral region may appear at this time, but these do not become as large or conspicuous as those in the dorso-lateral region.

As the specimens mature, the dark spots in the light dorsal region appear in about two to three irregular rows. The lateral spots are present in one or two rows, those in the dorso-lateral region being larger and usually more regular and well defined than those (when present) in the ventro-lateral region. The light dorsal ground pattern of the juvenile transforms into the fine vermicular mottling of the dorsal region of the adult; whereas the darker lateral pattern becomes an irregular dark reticulation enclosing lighter spots, this extending onto the belly in a lighter tone.

Necturus ***lödingi,*** sp. nov.

TYPE.—U.S.N.M. No. 6172, a female, collected in Eslava Creek, near Mobile, Alabama, Feb., 1918, by C. Löding, son of H. P. Löding, for whom this species is named (fig. 4). Total length 157 mm.; head 30 mm. (in length 5.23); tail 51.5 mm. (in length 3.05); width of head 20 mm.; depth of head 12 mm. (in width of head 1.75); width of body 18 mm.; depth of body 12 mm. (in width of body 1.50); costal grooves 14. Body sub-cylindric; head somewhat flattened; muzzle probe-like, round in outline and profile; origin of upper dermal border of tail above axillary region. Tooth formula: premaxillary, right 8, left 9; vomero-palatine, right 10, left 10; pterygoid, right 6, left 6. Skin tuberculated and rugose.

Color: above, slaty-black with small scattered light spots, the dark color extending down the sides as inconspicuous irregular saddles, and on the sides of the venter as a marbled pattern; the median third of the venter, breast, and throat immaculate; chin and forward portion of throat marbled; dark spots, obscured by the marbled pattern, barely discernible on the tail and rear of body; dark stripe on the canthus and eye obscured by the marbled pattern of the head.

PARATYPES.—There are two paratypes, taken by E. J. Wendt in Hall's Mill Creek near Mobile, Alabama, in August and September, 1935. U.S.N.M. 61752 was selected for the type because it is in a better state of preservation than the other two specimens. Five other specimens are known, all taken in Eslava Creek. According to Löding,[4] two of these were lost when the Charles

[4] Personal letter, Nov. 19, 1936.

Mohr collection was destroyed, and two, supposed to be stored in the Alabama Museum of Natural History, and one in the Julius Hurter collection cannot be located.

SUMMARY OF DIAGNOSTIC CHARACTERS.—Size small, specimens examined, all adult, varying from 147 mm. to 162 mm., ave. 155 mm.; weight in formalin, ave. 16.9 grams (approx. .6 oz.). Body subcylindric with head somewhat flattened; muzzle probe-like, rounded in outline and profile. Color dusky above, pale below, the dark color extending down the sides as irregular saddles which encroach onto the venter, throat, and chin as irregular marblings; dark

Figure 4. *Necturus lödingi*, sp. nov., the type, a mature female, natural size.

spots, especially in the posterior region and on the tail, are sometimes visible; dark stripe on canthus and eye obscured by marblings on head. Tooth formula: 8 (7–9), 10 (9–11), 6 (5–6). The skin is apparently more tuberculated and rugose than in any other species. Juveniles unknown.

Necturus maculosus (Rafinesque)

SERIES EXAMINED.—The series examined statistically consists of 16 adults from the Great Lakes drainage area, from Michigan and Wisconsin; and 12 adults from the Mississippi River drainage area, from Missouri and Indiana. In addition, a large number of adults from Wisconsin, Michigan, Ohio, Tennessee, Alabama (Tennessee system), Missouri, Arkansas, Kansas, and Oklahoma, were superficially examined and checked against the key. Juveniles from Wisconsin, Michigan, Pennsylvania, Tennessee, Missouri, and Oklahoma were examined.

SUMMARY OF DIAGNOSTIC CHARACTERS.—The largest and perhaps most irregularly marked and variable species of the genus; adults from about 200 mm. to 424 mm.,[5] average about 300 mm.; weight in formalin, average of

[5] Maximum size reported by Sherman F. Bishop in a statement to the author.

series of adults examined statistically, 189.5 grams (approx. 6.5 oz.). Head and body depressed, apparently more so than in any other species (except possibly *alabamensis*); muzzle wide and flat, definitely truncate. Ground pattern above a dark greenish, rusty, or ashy brown reticular mottling with obscure whitish interspaces, becoming more definitely white spotted laterally; the whole superimposed with a scattering of large, rounded, usually obscure, blue black spots. Dark spots in adult very variable in size and number, usually total less than 100, but occasionally higher (max. 139, min. 10, ave. 58, in the series examined); lateral spots not uniformly larger than the dorsal spots, or if so, not arranged in a dorso-lateral row, 0 to 11 scattered lateral spots between axilla and groin. Specimens of this species, after preservation, often develop a steel gray color in the epidermis which obscures the dermal spots and reticulations, and a sprinkling of black epidermal dots, with no relation to the dermal spots, is superimposed over the whole dorsal pattern (fig. 5, right). When this is not the case, the reticular ground pattern is more distinct (fig. 5, left). Abdomen pigmented laterally as above, but lighter, contrasting with a creamy white mid-ventral portion or wholly pigmented; a dark line with more or less indefinite margins extends along the canthus through the eye to the gills. Tooth formula: 12.7 (9–15), 13 (10–17), 6.5 (4–8).

Life History Data.—New born young show three dark brown or bluish stripes, one along the mid-dorsal line and one on each side. The mid-dorsal dark stripe widens on the top of the head, then narrows and terminates in a point on the top of the muzzle. The three dark stripes are separated by two light creamy brown or whitish stripes which run along the latero-dorsal region. On the head they spread apart just in front of the gills and converge on the snout. On the tail they extend along the base of the dermal border.

A series of light spots, extending from the axilla to the end of the tail, is seen on each side in the lower lateral region. In line with these, the lower side of the head shows a series of spots or a light stripe beginning just in front of the lower gill and extending forward to the angle of the jaw. The underparts are creamy white from the chin to the vent, and usually along the lower dermal border of the tail.

The age at which the juvenile pattern disappears varies with individuals. Some specimens lose it before they reach 100 mm., whereas others may show it up to 150 mm. or even larger. The dark spots of the adult usually begin to form as the stripes disappear, although they are scarcely discernible on melanistic juveniles. In large juveniles the reticular ground pattern of the adult is usually coarse in the region corresponding to the former position of the juvenile mid-dorsal black stripe. Along the latero-dorsal region, the position corresponding to the juvenile light stripes, the reticulation is usually finer, but this differentiation disappears with age. In the lateral region, the light areas in the meshes of the reticular pattern become scattered, fewer, and larger, producing a spotted rather than a mottled or reticular ground.

Necturus punctatus (Gibbes)

Type.—U.S.N.M. No. 11813, Santee River, South Carolina, (not seen by author).

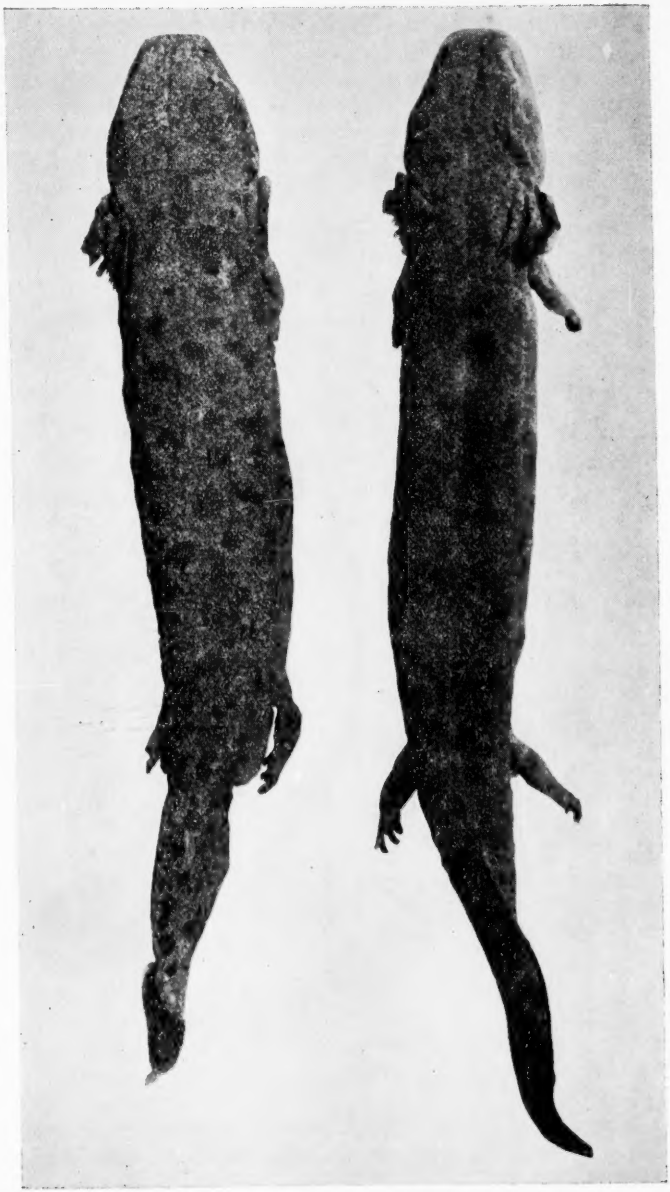


Figure 5. *Necturus maculosus* (Rafinesque), reduced ⅓. Left, a male; right, a female; both from Oshkosh, Wis.

SERIES EXAMINED.—This consists of 1 juvenile from the Ockmulgee River, Georgia; and 28 juveniles and 4 adults from the Neuse River System, North Carolina.

SUMMARY OF DIAGNOSTIC CHARACTERS.—Size small, adults ave. 122 mm.; weight in formalin ave. 9.9 grams (.3 oz.). Head and body moderately depressed; muzzle narrow, rounded in outline (fig. 6), rounded and swollen in profile. Uniform brown or slate color above with fine whitish dots, immaculate yellowish white below; dark spots invisible or practically

Figure 6. *Necturus punctatus* (Gibbes), natural size, from Raleigh, N.C.

so (about 20 obscure spots sometimes discernible on tail and rear of body). Tooth formula: 8 (7–9), 9 (9–10), 5 (5–6). The skin texture is smooth, even in the folds.

LIFE HISTORY DATA.—The juveniles of this species are almost uniform slaty brown above with scattered light dots. These are numerous on the tail,

especially on the dermal borders. The underparts are dirty white. There is little change of pattern between the juvenile and adult.

TENTATIVE KEY TO THE SPECIES OF *Necturus* HEREIN DEFINED

Tailed throughout life; external gills persistent throughout life; fore and hind limbs equally developed, four toes on each ..... *Necturus*

a. Body with rounded spots on a more or less reticulated or mottled ground pattern

b. The largest spots in dorso-lateral region between axilla and groin larger than the largest dorsal spots and arranged in a more or less definite row

c. Lateral spots in one regular, definite, dorso-lateral row; belly immaculate centrally; young unknown (Alabama waterdog) .. *N. alabamensis*

cc. Lateral spots less regular, the dorso-lateral row of large spots sometimes partly obscured by additional spots and reticulations; entire belly spotted and reticulated; 80 mm. young spotted (southeastern waterdog) ..... *N. lewisi*

bb. The largest dorso-lateral spots between axilla and groin normally not larger than the largest dorsal spots; or if larger not tending to form a dorso-lateral row and belly not reticulated

d. Dark spots numerous, normally over 150, over 15 on each side between axilla and groin; 80 mm. young spotted (southern waterdog) ..... *N. beyeri*

dd. Dark spots less numerous, normally less than 150, less than 15 on each side between axilla and groin; 80 mm. young striped (northern waterdog) ..... *N. maculosus*

aa. Not as above

e. Uniformly dark above and pale below; skin smooth, even in the folds; young neither spotted nor striped (least waterdog) ..... *N. punctatus*

ee. Clouded or marbled laterally and on sides of venter, skin tuberculated and rugose; young unknown (marbled waterdog) ..... *N. lödingi*

The third edition of the American Check List[6] lists three types of *Necturus,* which are here increased to six. Unfortunately, sufficiently large series for statistical analysis are not available in the case of all of the species. The 20 adults of *beyeri* from Calcasieu River were caught on catfish set lines and probably represent an average spawning run of that species. These have been compared in detail with 28 specimens of *maculosus* representing an average run of large adults from the Great Lakes and Mississippi River basins; an assortment of 12 species of *lewisi* from the Neuse and Tar River systems in North Carolina; 4 specimens of *punctatus* from North Carolina; 3 specimens of *lödingi* from Mobile, Ala.; and two known specimens of *alabamensis.* The results are summarized in Table 1.

On the basis of maximum lengths, the species rank in a diminishing series as follows: *maculosus, lewisi, beyeri, alabamensis, lödingi,* and *punctatus.* These specimens vary from the largest *maculosus* with a length of 387 mm. and a weight of 516.4 grams to the smallest adult *punctatus* with a length of 105 mm. and weight of 4.6 grams.

The total number of teeth seems to be, in a general way, correlated with size. Their present order on the basis of total number of teeth is as follows: *maculosus* (64), *lewisi* (55), *beyeri* (50), *lödingi* (48), *alabamensis* (46),

[6] Stejneger L., and T. Barbour. A Check List of North American Amphibians and Reptiles. Cambridge. 1933.

and *punctatus* (44). This order does not take into consideration the variations of the tooth formulae which are evidently correlated with variations of the muzzle shape.

The total length (L) divided by the length of the tail (T) does not vary greatly as to species, except for *punctatus* in which the quotient is about 14% smaller than the average for all other species, indicating a proportionately larger tail for that species.

On the basis of available figures *lödingi* shows a relatively long head; *beyeri* and *punctatus*, relatively short heads; and *maculosus*, *alabamensis* and *lewisi* are intermediate in this character.

The depth in the width, as measured at the widest part of the first third of the body, or degree of body "flatness," gives the following sequence: *maculosus*, *alabamensis*, *lödingi*, *lewisi*, *beyeri*, and *punctatus*.

In regard to the total number of dark spots in a diminishing series the species rank as follows: *beyeri*, *alabamensis*, *lewisi*, and *maculosus*, with *lödingi* and *punctatus* normally unspotted.

This study, as incomplete as it may be, indicates that the different characters vary in some cases independently, whereas in other cases there is evident correlation, such as tooth formula with shape of muzzle. All evidence points to the validity as species of the different types herein defined. A study of variations within the species, for lack of larger series, lies beyond the scope of this paper, but enough material of *maculosus* and *beyeri* was at hand to indicate the probability of racial variation in different water systems.

The 6 males of *N. beyeri* from the Calcasieu range in size from 160 mm. to 213 mm. (ave. 193 mm.) total length; the 12 females from 175 mm. to 223 mm. (ave. 208 mm.). The series of *maculosus* tabulated consists of 15 males ranging from 207 mm. to 345 mm. (ave. 299 mm.) and 12 females from 252 mm. to 387 mm., (ave. 313 mm.). Thus, in both species, the females average larger than the males. Both are also sexually dimorphic in regard to tail length, the tail being shorter in proportion to total length in the males. This dimorphism, however, is more pronounced in *beyeri*, in which species the tail of the male is proportionately shorter than for *maculosus*, whereas this ratio in the female is practically the same in these two species.

The *maculosus* adults average 189.5 grams, whereas the *beyeri* specimens from Calcasieu River average 36.4 grams. *N. maculosus* is considerably larger than *beyeri*, 50% greater in length and over 5 times the weight, on the basis of these figures.

The head in *beyeri* is shorter and obviously much less flattened than in *maculosus*. The muzzle is not as flat and wide as in *maculosus* and presents a more beak-like appearance. The body of *beyeri* is more cylindrical than in *maculosus*, the width averaging 11% greater than the depth, whereas in *maculosus* the width averages 42% greater than the depth. Correlated with the more cylindrical body of *beyeri* is the shape of the limbs and digits which are also more cylindrical.

There is very little overlapping in the tooth formulae of these two species. Their averages are *maculosus*, 12.6: 13: 6.5; and *beyeri*, 9: 10: 6.5. The premaxillary series is proportionately smaller in *beyeri* in conformity with the beak-like shape of the muzzle.

The ground color of *maculosus* is more variable than in any other species. It may be a dark greenish brown, a deep rusty brown, or an ashy brown, finely speckled or mottled obscurely with whitish specks and small spots. The ground pattern in *beyeri* is a brown (never grayish or greenish) reticulation enclosing numerous conspicuous rounded or irregular whitish spots.

TABLE I

SUMMARY OF STATISTICS USED IN DEFINING THE SPECIES OF *Necturus*

		alabamensis	*beyeri*	*lewisi*	*lödingi*	*maculosus*	*punctatus*
TOTAL	min.	168	160	168	147	207	105
LENGTH	max.	180	223	276	162	387	142
(in mm.)	ave.	174	203	202	155	306	122
WEIGHT	min.	17.7	26.3	24.5	13.2	42.7	4.6
(in grams)	max.	31.0	52.2	80.0	23.2	516.4	14.2
	ave.	24.3	36.4	44.4	16.9	189.5	9.9
TAIL IN	min.	2.89	2.84	2.41	3.05	2.85	2.43
LENGTH	max.	3.35	3.29	3.88	3.44	3.45	2.75
	ave.	3.12	2.92	3.15	3.25	3.12	2.58
HEAD IN	min.	5.60	5.33	5.13	5.23	5.16	5.61
LENGTH	max.	6.00	6.63	6.00	5.65	6.40	6.17
	ave.	5.80	5.86	5.55	5.41	5.63	5.89
DEPTH IN	min.	1.14	1.00	1.00	1.15	1.00	1.00
WIDTH	max.	1.42	1.50	1.54	1.50	2.44	1.17
	ave.	1.28	1.11	1.26	1.27	1.42	1.09
PREMAX-	min.	8	7	10	7	9	7
ILLARY	max.	11	12	14	9	15	9
TEETH	ave.	9	9	11	7.8	12.7	8
VOMERO-	min.	6	9	9	9	10	9
PALATINE	max.	10	12	12	11	17	10
TEETH	ave.	9	9.8	11	10	13	9
PTERY-	min.	5	5	5	5	4	5
GOID	max.	6	8	7	6	8	6
TEETH	ave.	5.5	6.5	5.7	6	6.5	5
SPOTS	min.	80	189	52	0	10	0
TOTAL	max.	104	393	115	0	139	20
	ave.	92	265	88	0	58	2
SPOTS	min.	7	17	8	0	0	0
LATERAL	max.	8	53	15	0	11	0
	ave.	7.5	31	11	0	6	0

In *maculosus* the gound pattern is superimposed with large roundish, more or less obscure blue-black spots, or mottlings, very variable in number, the total number on the entire animal being normally less than 150 (varying from about 10 to about 140 except in rare instances). Numerous black dots are also visible on the upper epidermal surfaces of many preserved specimens. These are spaced with no relationship to the other markings. In *beyeri*, conspicuous dark brown (almost black) spots are superimposed in irregular rows upon the reticular ground pattern, the total number being rarely less than 200 (189 to 393 in specimens examined) and other than these, there are no black dots.

Although the dark spots in *maculosus* are very irregular, usually about 8 (4 to 10) longitudinal rows can be counted when they are not completely obscured. There are 5 to 10 lateral spots in about 2 (rarely 1) irregular rows on each side between the axilla and groin. These are usually not larger than the dorsal spots. The dark spots in *beyeri,* closer together, much more numerous, and relatively much smaller than on *maculosus,* appear in about 12 to 16 irregular rows. They are more consistently uniform in size in the dorsal and lateral regions, but diminished in size or may be absent entirely on the belly. In the lateral region of *beyeri,* between the axilla and groin, there are a total of about 20 to 50 spots in 3 or 4 irregular longitudinal rows and as many as 12 to 14 in a single row.

The dorso-lateral pigmentation of *maculosus,* usually without the dark spots, encroaches onto the otherwise creamy white belly in varying degrees, sometimes with sharp contrasts between the dark and the light. In some specimens the light ventral color may be absent or limited to a narrow mid-ventral stripe and the region around the vent. Sometimes the underside is spotted as above. The palms and soles are yellowish white. In *beyeri,* the brown reticular pattern of the back and sides becomes less intense below and shows less contrast to the ground color, and there is never a conspicuous creamy white mid-ventral stripe as is sometimes present in *maculosus.* The palms and soles in *beyeri* are not conspicuously differentiated.

Of the 20 specimens of *beyeri* from Calcasieu River, only 3 have a tendency to reduction of the ventral spots, and none shows the entire absence of these spots as is the case with all specimens of record east of the Mississippi Valley. It would seem that the tendency toward an immaculate abdomen in these specimens may indicate a different racial trend in the East Gulf Coastal Plain from that in the West Gulf Coastal Plain as is the case with a number of other amphibians and reptiles, the continuity of whose range is interrupted by the Mississippi Alluvial Plain. There are not enough records, however, to judge the significance of this trend.

N. lewisi is in some respects more like *maculosus* than is *beyeri,* but it seems preferable to regard it as an independent species.[7] The dominant color is an eggplant purple or purple brown, not the blue black of *maculosus.* The dorsal ground pattern on *lewisi* is more mottled and less reticulated than on *beyeri.* The dark spots on *lewisi* form about 6 to 8 somewhat uniform rows, plus a less uniform row or just occasional spots in the mid-dorsal and in the mid-ventral regions. The total number of spots averages 88, within the range of *maculosus,* but there is a consistent difference in the size of the dorso-lateral spots which are about twice the diameter of the dorsal spots and somewhat regularly spaced. Rarely are the lateral spots on *maculosus* larger than the dorsal spots and they are never regularly spaced nor tending to form a definite row. On *lewisi,* there are 5 to 15 large spots between axilla and groin, a far smaller number than in *beyeri.*

On *maculosus,* the dark pigmentation of the upper parts often obscures the dark line on the canthus and through the eye; on *beyeri* the canthus and eye show mottlings with a linear tendency but no distinct line; and on *lewisi* there is a distinct dark line on the canthus extending through the eye.

[7] *Loc. cit.*

As one becomes more familiar with the different species he can discern other color and physiognomic characters which are as yet difficult to analyze.

N. alabamensis, the smallest of the spotted forms, is no doubt the most conspicuously marked of all species, not excepting *beyeri*, if one can judge from the limited material available. Its flattened muzzle, head, and body are suggestive of *maculosus*, but its far smaller adult form, and its distinctive pattern are sufficient criteria to merit for it the rank of a species. It can also be distinguished from *lewisi* by its smaller size, more flattened shape, its immaculate belly, and lesser number and more regular linear pattern of spots.

Specimens of *lödingi*, listed by Löding as *punctatus*,[8] are readily distinguishable from that species. They are darker and show lateral saddles as well as marblings on the sides of the belly, of which there is never the slightest suggestion in *punctatus*. Although the chin of *punctatus* is not pigmented or only lightly so, this southern Alabama species shows considerable cloudiness on the underside of the head.

The scattered light spots of *lödingi* are not comparable to the uniformly distributed white points of *punctatus*, and the tuberculated and rugose skin contrasts with the smooth surface of the latter species.

Ecology

All species of *Necturus* are perennially aquatic, and apparently largely nocturnal. They are rapacious in their feeding habits, and there is probably little selectivity, the animals feeding largely on whatever is available in their habitats. In fact, any apparent selectivity is perhaps due to habitat preference rather than to food preference. It is no doubt because of their secretive habits that crawfish and insect larvae, organisms with similar habitat predilections, top their food list.

Brimley's observations on *punctatus* and *lewisi*[9] and the observations of Bishop[10] and others on *maculosus* point to a clear, permanently running, stream habitat for these species. The writer's own observations on the streams in which his and other collections were made indicate that all of the new species belong to what are generally called clear streams (really spring-fed streams), although they vary much in character and some may be muddied considerably during floods. The genus is apparently absent from bayous and other sluggish or stagnant waters, excepting spring-fed lakes or ponds to which they have access.

Necturus maculosus occurs throughout its range wherever the bottom is covered with suitable material for hiding places, such as flat rocks, logs, or wood slabs. Bishop[11] states that the amount of available food in a stream is a factor governing the abundance of *maculosus* only when the stream provides suitable hiding places and nesting sites.

N. punctatus has been reported from rivers and rice field ditches from North Carolina to Georgia. Brimley's studies would indicate that it is confined only to the lower, more sluggish, courses of streams in those states and

[8] Löding, H. P. A preliminary catalogue of Alabama amphibians and reptiles. *Ala. Mus. Nat. Hist., Mus. Paper* No. 5, 1922.

[9] *Loc. cit.*

[10] Bishop, S. C. 1927. The amphibians and reptiles of Allegany State Park. *N.Y. State Mus. Handbook*, No. 3, 1937.

[11] *Loc. cit.*

therefore belongs strictly to the Atlantic Coastal Plain. It would seem that the rice field ditch habitat is incidental to the diversion of the water supply by nearby streams. Brimley found adult *punctatus* where bunches of dead leaves and other trash had caught against the banks below the water. The little evidence would indicate that this species is not an inhabitant of rocky streams and the same would seem to apply to its associate *lewisi*, although the latter seems to ascend the streams to higher levels. Brimley[12] states that *punctatus* occurs with fish species which show mainly lowland affinities.

Necturus beyeri has been taken only in sandy, spring-fed, streams in waters approximating an average of 70° F., much warmer than the habitat of *maculosus*. It has been found both east and west of the Mississippi Valley, but has never been taken or reported from sluggish or muddy waters such as the bayous, lakes, and rivers of the Mississippi system in Louisiana. *Micropterus pseudaplites* is the dominant fish in streams where this *Necturus* has been taken. Other fish associates are *Ambloplites ariommus, Xenotus megalotus, Fundulus notatus, Hadropterus nigrofasciatus, Notropis cercostigma, Notropis longirostris, Moxostoma poecilurum* and *Schilbeodes leptacanthus*.

There is some evidence of a late winter and early spring courtship migration of the southern species of water dogs. All adults of *beyeri* on record were taken on live bait during the winter and early spring months and were in gravid condition, yet, in spite of the fact that more fishing is done at other seasons, they have never been taken during those periods. Similar reports regarding the waterdogs of that region are given by natives near Tuscaloosa. Thus, it seems that nesting time is in early spring.

I saw young larvae, undoubtedly of *beyeri*, in the Pearl River during an April freshet about 20 years ago and those taken recently (April, 1937) in a spring-fed feeder of Bayou Lacombe confirm this evidence.

What becomes of the adults of *beyeri* during the summer is as yet a puzzle. The beak-like muzzle and cylindric head and body would seem to indicate a burrowing habit, and probably the adults retire to burrows of their own making or appropriate those made by crawfish or other creatures. The ground in the valleys of these spring-fed streams is profusely tunnelled by other burrowing creatures, and water in ponds and pools in old stream beds rises and falls simultaneously with the stream whether or not there was a local rain. *Siren lacertina* and the two species of *Amphiuma*, subterranean at the level of the water table but rarely seen in the streams themselves, travel through these tunnels from pond to pond. Two juvenile specimens of *beyeri* were taken in such a pond associated with juvenile specimens of *Siren lacertina, Amphiuma means*, and *A. tridactylum;* and two others taken under a board at the edge of a small spring branch were found under conditions approximating those of *Amphiuma* tunnels—indicating the retiring habit of the species. Larvae and juveniles taken in April, 1937, were under dead leaves in one to three feet of water.

Judging by shape of body, head, and muzzle, it would seem that *maculosus* and *alabamensis* are better adapted for hiding under flat rocks, whereas the other four species are adapted for burrowing or hiding under more yield-

[12] Personal letter to author, May 29, 1937.

ing materials, such as leaves, or appropriating tunnels such as left by rotted roots or made by *Amphiuma* and crawfish. Their known distribution, outlined below, has a bearing on these features.

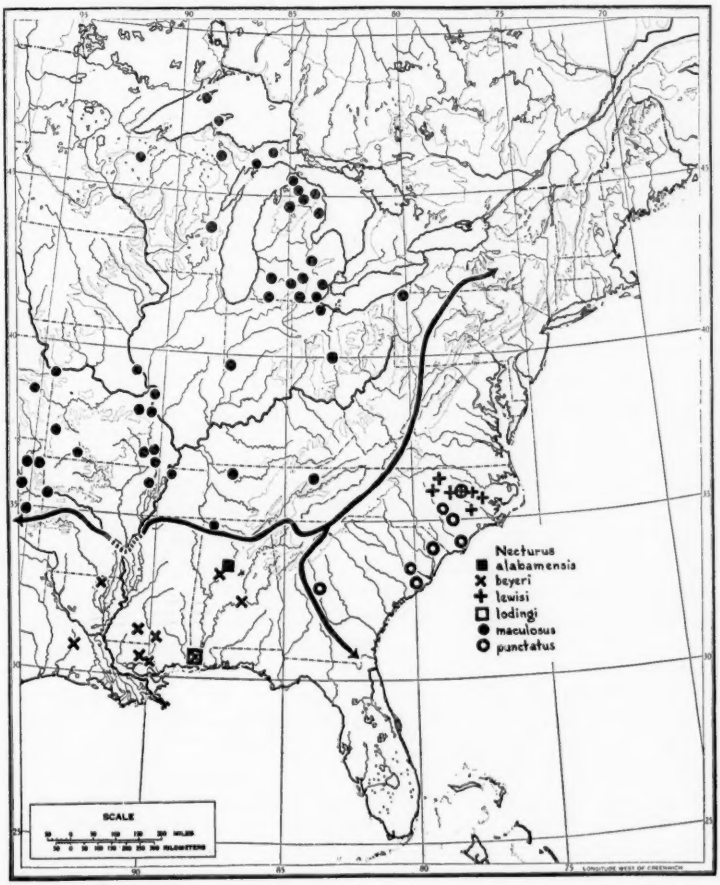


Figure 7. Map showing the distribution of the genus *Necturus*, as based on specimens examined. The northern limits of *N. maculosus* were not considered in this study. The bold line indicates the watersheds which apparently divide the genus into three zoogeographic zones.

Distribution

Without further material from the southern states, it is difficult to define the ranges of the different species of *Necturus*. *N. beyeri* and *lewisi* were formerly included with *maculosus* in defining the geographic range of that species. As with the southern rock bass, *Ambloplites ariommus*, the southern

waterdog probably covers a large part of the southern gulf drainage area (fig. 7), excluding perhaps the mud-bottomed lakes, rivers, and bayous of the Mississippi Alluvial Valley and Gulf coastal estuaries.

A striking situation exists in Alabama, apparently the center of distribution of the genus *Necturus*. Three of the described species are known from the Mobile River System: *beyeri* from the Alabama River, *alabamensis* and *beyeri* from the Black Warrior, and *lödingi* and *beyeri* from creeks flowing into upper Mobile Bay. Thus, in Alabama, *beyeri* overlaps the known ranges of the other two Alabama species, one from the plateau and one from the coastal plain.

Across the divide in Georgia, in the southern part of the Atlantic Coastal Plain, is found *punctatus*, the least waterdog, but none of the Gulf Drainage species. Further north in the Coastal Plain of North Carolina, the southeastern waterdog, *lewisi*, and the least waterdog are known to occur together in Little River, a tributary of the Neuse River System. To what extent the ranges of these two species overlap and to what extent their conditions of existence differ is not yet known.

The genus *Necturus* is thus distributed over three distinct watersheds, more or less isolated from each other by barriers to certain types of perrenially aquatic animals—the Atlantic Coastal Plain from the Interior Plateaus by the Appalachian divide and from the Gulf Coastal Plain by the Georgia divide; and the Gulf Coastal Plain isolated from the interior plateaus by the divide in northern Alabama and Mississippi, the Ouachita Mountains in Arkansas, the San Bois Mountains in Oklahoma, and by the mud-bottom, silt-bearing waterways of the lower Missouri Valley.

Occasionally northern species, such as the walleye pike, *Stizostedion vitreum*, break through the muddy barrier of the Mississippi flood plain during times of heavy floods, but apparently they do not thrive in the southern habitat, even in clearer waters. As other species sometimes associated with *Necturus maculosus* (such as northern smallmouth bass, *Micropterus dolomieu* and the northern rock bass, *Ambloplites rupestris*) do not get through this tension zone, it is not surprising to find that *Necturus maculosus* does not run the gauntlet of the lower Mississippi River with its absence of hiding places for a species of this nature. The Gulf coastal and interior plateau habitats themselves would no doubt serve as barriers, because of the significant chemical, physical, and biotic differences, to occasional specimens of northern or southern species respectively, which might traverse the Mississippi flood plain.

Excepting the two species of *Necturus* known only from small areas in Alabama, the probable ranges of the remaining four species of the genus may be tentatively defined as follows: *lewisi* and *punctatus*, Atlantic Coastal Plain, exclusive of Florida; *beyeri*, Gulf Coastal Plain, exclusive of Mississippi Alluvial plain; *maculosus*, Mississippi and its tributaries from the Arkansas River northward, Great Lakes Drainage area, and upper Hudson River system (probably since the opening of the Erie Canal).

SOUTHERN BIOLOGY SUPPLY HOUSE, NEW ORLEANS, LOUISIANA.

Herpetological Notes

DESIGNATION OF GENOTYPE FOR *HYLAPLESIA* BOIE.—In 1826 Boie (Férrusac's Bull. Sci. Nat., 9: 239) instituted the genus *Hysaplesia* (apparently a misprint for *Hylaplesia* as substituted in the German rendering in Oken's Isis, 1827: 294) for a genus of treetoads, in which he included seven specific names without the designation or indication of a type, viz: *H. borbonica* K. et V.H. n. esp.; *H. achatina* K. et V.H. n. esp.; *Hyla trivittata* Spix; *H. nigerrima* Spix; *H. punctata* Daud.; *H. tinctoria* Daud.; *luteola* P. Max. The first two names as *nomina nuda*[1] have no status in nomenclature and are consequently unavailable as genotypes. Fitzinger's subsequent designation of "*Hylaples. achatina* Boie" (1843, Synops. Rept.: 31) has therefore no standing. None of the four previously described species possesses the generic name *Hylaplesia* as its specific or subspecific name; none of them is listed as a *species inquirendae* nor is any doubtfully referred to it, nor has any of them as yet been designated as a genotype of *Hylaplesia* by any subsequent author, as far as I know. I therefore avail myself of the privilege according to the International Code, article 30, II, g, to select *Hyla punctata* Daudin as the type. By this action *Hylaplesia* becomes a synonym of *Hyla* and will cease to be a source of future confusion in herpetological nomenclature.—LEONHARD STEJNEGER, *U.S. National Museum, Washington, D.C.*

OVOVIVIPARITY IN *TRACHYBOA*.—The Museum of Comparative Zoology has from time to time for many years been receiving reptiles from Dr. Herbert C. Clark, Director of the Gorgas Memorial Laboratory in Panama. In this way statistical information is being obtained regarding the proportional incidence of the various poisonous species in selected areas of the Republic. In one of these collections made in April, 1936, in the vicinity of the old gold mines of Santa Cruz de Cana in the Province of Darien there appeared a beautiful specimen of the rare *Trachyboa boulengeri* Peracca, a species which we had only had, in the past, from the rain forest of the Choco of Colombia—taken also at a famous mining site—the platinum mines of Andagoya.

Our Cana snake was so bulky that I suggested to my colleague Mr. Arthur Loveridge that we slit it open to see upon what the snake had been feeding. Upon examination we found not food but six embryos each about four inches long with somewhat less than half, I should say, of the original amount of yolk attached. The young would certainly have grown an inch or more had they come to term, but even now the pattern is distinctly visible and most interesting to note is the bright yellow tail tip which emphasizes at once the affinity with *Tropidophis*. Not that this character is peculiar to these boids, for it must be a character as ancient as black temporal stripes, cross bands between the eyes, loreal stripes, and other color features which are probably among the most ancient and stable of reptilian characters. Far more so than characters of size, dentition or the characters of squamation which we consider basic in character since they are taxonomically so constantly useful.

One hesitates to speculate but one naturally wonders whether the agkistrodons sprang from some early ophidian stock having a common ancestry with these little terrestrial boids for the brilliant yellow tails of young moccasins are strikingly similar. I hardly expect that this notion is worthy of serious consideration.—T. BARBOUR, *Museum of Comparative Zoology, Cambridge, Massachusetts.*

HETERODON CONTORTRIX IN NEW HAMPSHIRE.—On September 26, 1936, the writer observed a specimen of the hog-nosed snake, *Heterodon contortrix*, in Nashua, New Hampshire. The snake was a small one, approximately a foot long. It was lying in a bed of moss beneath a thicket of white pine and gray birch trees. The morning was cool, and the creature appeared somewhat sluggish, for although it flattened the anterior end of the body and hissed, it made no movement as if to strike beyond drawing the head back slowly whenever my pokings at it seemed to come too close. It is thought that this may be the first record of this species for New Hampshire.—MILTON F. CROWELL, *Nashua, New Hampshire.*

[1] Consequently names of "*species inquirendae* from the standpoint of the author of the generic name at the time of its publication" (Intern. Code, art. 30, II-*e*, *β*).

CLARK'S WATER-SNAKE ON THE MID-TEXAS COAST.—On June 15, 1936, I collected a water-snake on First Chain Islands, 18 miles southwest of Port O'Connor, Calhoun County, Texas. This locality is about 47 miles northeast of Corpus Christi. The specimen was taken in heavy grass on a small brush and grass-covered island (100 x 600 ft.), a half mile or more from the mainland. In action and behavior the snake reminded me strongly of a garter snake and I was puzzled as to its identity. Confined in a small bag and unwittingly exposed to the sun it died the day following capture. With no preservative at hand I prepared the specimen as a flat skin, after making color notes and measurements. This skin was examined later by Dr. Frank N. Blanchard, to whom I am indebted for determining the species as *Natrix clarkii*. A second specimen, dead and dessicated, was noted on a small island (Vingt-un) in Galveston Bay, below Houston.

The Chain Islands snake, a female, measured 695 mm. in total length, with a tail measurement of 121 mm. Scale count 20-21-19; ventrals +132; caudals +46. The snake contained twelve eggs, with small embryos. The eggs averaged approximately 15 x 19 mm.

Although this specimen seems to agree in scutellation with available descriptions this is not true of the coloration shown by the fresh snake. There is a marked discrepancy between the descriptions of Cope[1] and Ditmars[2] and each differs from the specimen under discussion. This latter I would describe as follows: Olive brown above, with three stripes of pale olive. The mid-dorsal stripe is three scales wide; those on the upper sides cover the sixth and seventh scale rows and are paler than the mid-dorsal, being almost pale olive cream. I might point out that these stripes leave an olive brown dorso-lateral area two scales wide and a similarly colored lateral area three and a half scales wide. The belly has a central stripe of sulphur yellow on brick-red ground, the ends of ventrals and first one and a half scale rows pale olive cream. After my return to Charleston I checked these colors with Ridgway's "Color Standards and Nomenclature." As nearly as I can judge, relying on memory and the half-dried skin, the ventral colors approximate the Cream-Buff and Morocco Red of Ridgway.

Stejneger and Barbour (Check List, 1933) give the range of *Natrix clarkii* as "Coastal regions of northwest Florida to Texas" and the type locality as Indianola, Texas. This point I have been unable to locate definitely but am under the impression that it is on the northeast coast of Texas. If this be the case, the specimens above mentioned, if considered typical *clarkii*, constitute an extension of known range.—E. B. CHAMBERLAIN, *The Charleston Museum, Charleston, S.C.*

NOTES ON THE LONGEVITY OF AN *AMBYSTOMA* IN CAPTIVITY.—In COPEIA for August 15, 1919, a salamander, *Ambystoma maculatum*, captured as an adult in April, 1912, was recorded as having been kept in captivity for seven years. Another note, in the issue of October 25, 1928, told of its continued welfare, and this has been quoted by Flower (1936: 380).[1] The vivarium in which it was kept had passed into the possession of Dr. Alfred O. Gross, of Bowdoin College, but the *Ambystoma* continued to thrive on a diet of earthworms, Hamburger steak and the like.

In 1934 I heard that the salamander was dead and upon writing for details Dr. Gross replied that the vivarium had been left with friends while his family was away for the summer. Upon their return the *Ambystoma* was gone. He writes:

> There were no remains of any sort in the vivarium and as it was not removed and could not possibly have escaped, we are inclined to believe that the survivor swallowed his companion. Do you think this possible? The people who rented our house perhaps did not feed them as we asked them to do and perhaps hunger prompted him to become cannibalistic. Whatever happened occurred between July 1 and Sept. 1, 1934.

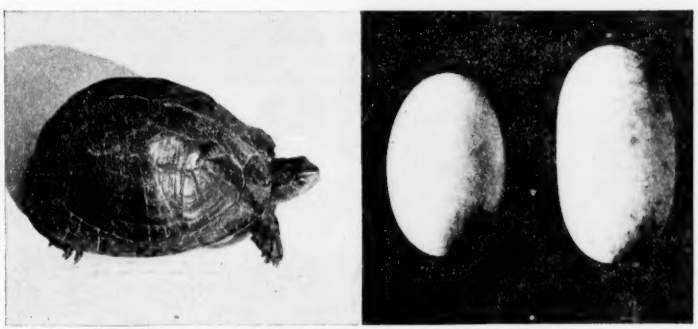
I am inclined to doubt whether a salamander could swallow another of the same size. It is unfortunate that the incident took place during Dr. Gross's absence and that he could only report that the animal was missing upon his return. Possibly some child took it out and lost it but in any case I do not think that the failure to find remains in the moss that presumably covered the vivarium floor necessarily means that it could not have died there. Moss is usually acid and the decay of the animal would make it more so. The bones of a salamander are not large or very hard and I think that if it rotted in the moss the skeleton would be largely disarticulated, very likely partially dissolved and what was left blackened and easily overlooked.

[1] Ann. Rep. U. S. Nation. Mus., 1898: 988.
[2] The Reptile Book, 1907: 245.
[1] Flower, Stanley Smyth. Further notes on the duration of life in animals.—II. Amphibians. Proc. Zool. Soc. London, 1936: 369–394.

Whatever the answer may be, the question that I asked in 1919: "Do frogs and salamanders die of old age or continue to live until killed by some of their natural enemies?" must remain unanswered by this particular salamander. When captured it was fully grown, probably as much as three years old, so its record of 22 years in captivity makes it at least 25 years old before its disappearance. The remaining one, that was suspected of eating it, was taken as a larva either in 1915 or 1916. Therefore it has lived nearly 21 years and may yet survive to make a record of its own.—PHILIP H. POPE, *Whitman College, Walla Walla, Washington.*

NOTES ON A FLORIDA BOX-TURTLE, *TERRAPENE BAURI* TAYLOR, KEPT UNDER MARYLAND CONDITIONS.—On May 23, 1935, Gerrit S. Miller, Jr., of the United States National Museum turned over to me a fine, live, adult female of *Terrapene bauri,* which had been collected a few days previously at Big Pine Key, Florida, by Howard Hinson. The specimen was typically and beautifully marked as the accompanying photograph (see figure) shows. It measured 134.5 mm. in length—from front to rear margin of carapace.

This specimen was placed at once in the back section of my garden at Takoma Park, Maryland, adjoining the woods, in company with several individuals of *Terrapene carolina* and one adult female of *Terrapene ornata.* For several days this female was observed living in nearly all respects the same as the individuals of *T. carolina* except that she never mated with any of the males of the latter species.



The Florida box-turtle, *Terrapene bauri* Taylor. To left: side view of female; much reduced. To right: egg of *Terrapene bauri* (larger) photographed with one of *Terrapene carolina* (smaller) for comparison; slightly reduced.

On June 20 the female was observed digging her egg hole. She did this in the same manner as does *T. carolina.* The egg hole was finished soon after 9:21 P.M., an egg was laid at 9:47 P.M., and by 10:11 P.M. the female had about finished filling in the egg hole. On August 24 I dug into the nest and found a single egg which proved to be infertile. This egg (see figure) was considerably larger than the average for *T. carolina,* and, as the photograph shows, the shape was not typical of our native Maryland species.

The specimen of *T. bauri* was left in the open to see if she would hibernate, and if so, to see if she would survive our Maryland winter. The following winter (1935–36) proved to be the most severe for our state in many years, the temperature being near zero for several days. However, there was a good cover of snow on the ground. *T. bauri* crawled under the ground litter at the approach of cold weather, and even penetrated somewhat into the soil below the litter. After going down she was seen no more until March 7, 1936, when I investigated and found her dead in her hibernating quarters. The top of the carapace was one and one-half inches below the packed ground litter. I further observed, within less than 3 feet of *T. bauri* and at about the same depth below the surface as the Florida box-turtle, four individuals of *T. carolina* which were alive and in excellent condition, although the ground had been frozen for many inches below them during the severe previous winter.—H. E. EWING, *U.S. National Museum, Washington, D.C.*

SNAKES FROM AN ANT HILL.—On September 25, 1934, two smooth green snakes (*Opheodrys vernalis*) were killed on an ant hill located on the farm of the author. The ant hill, a flat mound about six inches high and three feet in diameter, was occupied by black ants, probably of the genus *Formica*. It was located among hazel and hawthorn scrub at the edge of a small opening, which is surrounded by oak and aspen woods. Not far away are some willow swamps and muskegs, such as are commonly found along the Assiniboine River which is about a mile distant.

The hill was provided with the normal entrances, some of which seemed to be slightly larger than usual. It had a rather abandoned appearance, although a few ants were still crawling about. Later digging showed that very few ants were present, but it is impossible to say whether they had abandoned it voluntarily or had been eaten by the snakes. After the hill had been carefully examined, six red-bellied snakes (*Storeria occipito-maculata*), discovered by digging into the hill by hand, were removed. The next day four more snakes were dug out, and it became evident that a great many more remained in the deeper parts of the hill.

The spot was again visited on October 6. Careful digging with a spade revealed that the lower galleries were almost alive with snakes. In forty minutes of digging 75 snakes were removed. On October 10 the hill was completely dug out. The diameter of the hill increased with the depth, so that the excavation took on the form of an inverted funnel. Some of the galleries were quite closely packed with snakes, so that five or six were often exposed with one shovelful of sand. Water was found at a depth of four feet nine inches. While no snakes were found below the water level, some had the lower parts of their bodies submerged in it. All the snakes that were in contact with the water or close to its level had their heads up, pointed toward the surface, and were in a semi-dormant condition. In the higher galleries they were found in all positions, usually singly, although occasionally two, three or more were closely coiled together. A total of 181 snakes was added to those previously taken out, so that 257 snakes in all were removed from this single hill. Eight of these were *Thamnophis radix*, 101 were *Storeria occipito-maculata*, and 148 *Opheodrys vernalis*.

The garter snakes, which were not adult, were found between one foot and three feet down, and were all quite active. Individuals of the other two species were scattered from close to the surface down to water level, some of the green snakes being partly submerged. Most of the large adults were lowest down, while the majority of the smaller individuals were nearest the surface. This suggests that the adults may have arrived first and were followed later by the younger ones.

Most of the snakes were sent to Mr. Clyde Patch, of the National Museum of Canada, who very kindly confirmed the identifications of the three species, and supplied the following measurements.

Four *Thamnophis radix* measured 221, 294, 338 and 344 mm. Seventy-six *Storeria occipito-maculata* varied from 112 to 303 mm., averaging 217.6 mm. Of 112 *Opheodrys vernalis* measured, the shortest was 116 mm., the longest 428 mm., and the average 300.3 mm.—STUART CRIDDLE, *Treesbank, Manitoba.*

WRIGHT'S BULLFROG IN SOUTH CAROLINA.—While the Wrights, in their *Handbook of Frogs and Toads,* include coastal South Carolina in the range given for *Rana heckscheri,* I am unaware of any published records for this state. Accordingly it may be worthwhile to place on record several specimens in the collection of the Charleston Museum.

On February 22, 1935, Ivan R. Tomkins took a 50 mm. specimen of *heckscheri* at Causton's Bluff, near Savannah, Georgia. On June 12, 1935, William W. Humphreys of Charleston brought in a frog because it had only one eye. This, and two normal specimens secured at Pon Pon, on the Edisto River about 25 miles northwest of Charleston, also proved to be *heckscheri*. The abnormal specimen is 46 mm. long. It has no trace of a left eye or eye opening; the left side of the head shows no bulge, the skin being smooth except for a few small tubercles, comparable to those on the right eyelid.

The largest Pon Pon specimen measures 60 mm. in length. These frogs were taken in flooded sand pits near the Edisto River. Mr. Humphreys states that they were numerous but hard to secure for they proved very wary, immediately leaping into the four to six feet of water in the large pits when approached.—E. B. CHAMBERLAIN, *The Charleston Museum, Charleston, South Carolina.*

REVIEWS AND COMMENTS

ECOLOGICAL ANIMAL GEOGRAPHY. AN AUTHORIZED, REWRITTEN EDITION BASED ON TIERGEOGRAPHIE AUF OEKOLOGISCHER GRUNDLAGE, by Richard Hesse. W. C. Allee, and Karl P. Schmidt. John Wiley & Sons, New York, 1937: i–xiv, 1–597, 135 figs. $6.00.—Too often students of biology devote their lives to studying small segments of special fields, magnifying their little problem far out of proportion to its value, and often making no effort to interpret their findings in terms of fundamental principles. To guard against such dangers, we must pause frequently in our work to survey the broad vistas of Biology. So appalling is the magnitude and dispersal of the literature, however, that it is only in those occasional and rare textbooks that collect these scattered threads and weave them into a pattern, that we can attain a perspective of the subject. *Ecological Animal Geography* is so successful a text of this kind that biologists can scarcely afford to be without it. In one volume the authors have managed to compress an amazing array of facts bearing on the distribution of marine, aquatic and land animals. Each chapter contains a copious bibliography, leading readers to key references. Though these are not always the most recent references, nor even always the best (for a work on salmon, for example, cf. Jordan and Evermann, 1896 and Doflein, 1900, "Von den Antillen zum fernen Westen"—a residue, presumably of the German edition). The book is indexed, but not very thoroughly—an important point in a book of this kind. Yet in the face of such a tremendous work, these are slight faults, which no doubt will disappear in future editions.—L. A. WALFORD, *Bureau of Fisheries, Washington, D.C.*

MARINE GAME FISHES OF THE PACIFIC COAST FROM ALASKA TO THE EQUATOR. By Lionel A. Walford. A Contribution from the Santa Barbara Museum of Natural History. University of California Press, Berkeley, 1937: i–xxix, 1–205, 26 text figs., col. frontisp., 1 map, and pls. 1–69 (37 col.). $5.00.—One of the most pleasant of my last acts as retiring Ichthyological Editor of COPEIA is to review this magnificent volume by my successor, Dr. Walford. *Marine Game Fishes of the Pacific Coast* is one of the most attractive fish books ever published, and the colored reproductions of many of the game fishes are to my mind the truest to life of any I have ever seen. Those based on colored photographs should almost sound the death knell on colored fish illustrations produced in any other way. The text is written in a very readable style, that should make the work interesting and valuable to a large circle of readers—big game fishermen, ichthyologists, naturalists and others. Simple but adequate keys and descriptions are given, along with many notes on habits and general natural history. Throughout the text, as well as in separate sections, is material written for the interest and instruction of the deep-sea angler. The work is one of high accuracy, and contains a large and real ichthyological contribution. New species discovered in the course of the author's field work have been diagnosed elsewhere, but are figured and further described and discussed in this work. Much of the research basic to this volume was conducted by the author off southern California and Middle America; the chapter on the Salmonidae is almost all that refers to the region farther north. As the author admits, it proved very difficult to differentiate game fishes from others, so as to have his selections meet with general approval. His final decision was to treat those species ordinarily caught by trolling, and generally to include also the other species of the region belonging to families containing such species.—CARL L. HUBBS, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

SNAKES ALIVE AND HOW THEY LIVE. By Clifford H. Pope. Viking Press, New York: XII + 238, 65 halftone illus., 28 figs. $2.50.—The title of this book is justified in text and illustration, for no book on snakes since Catherine Hopley's in 1882 gives such a lively view of snakes as living creatures, and none has been so eminently "readable." Happily, readability is combined with an up-to-dateness which reflects the author's comprehensive knowledge of technical herpetological literature. The great amount of information packed into the twenty general chapters is extraordinary. As an

example of this feature, we learn of the laying by the night adder of successive fertile clutches of eggs after one mating, an extremely important observation, and one which opens a whole new field of investigation. This appears in no other recent book. The appendix with a key to the identification of North American snakes is especially welcome since Blanchard's "Key" of 1924, on which it is modelled, is out of print.

By no means the least of the merits of this book is the frequent mention of his colleagues in this country and abroad in reporting their observations. Best of all, the author's own personality is introduced to the reader in the opening chapter, and by the end of the book his warm and sincere interest in his subject seems to be stamped on every page. The reader thus is introduced to the personalities interested in snakes, and becomes aware that the search for knowledge in this field is actively in progress.—KARL P. SCHMIDT, *Field Museum of Natural History, Chicago, Illinois.*

BLACK BASS LORE. By Paul Gallaher. G. P. Putnam's Sons, New York, 1937: i–xviii, 1–236. $2.75.—This book for anglers by an angler is apparently intended to replace Henshall's *Book of the Black Bass* as a standard on the subject. The directions given for various methods of fishing are the work of a patient teacher with a proper consideration for not-too-quick students. The discussion of natural history is brief and subordinated to fishing lore. As usual with books of this sort, there is a pretty heavy dose of philosophy and sentiment which must be waded through to get at the useful facts. There is no index.—L. A. WALFORD, *Bureau of Fisheries, Washington, D.C.*

FISHING FOR SALMON AND TROUT. By Ray Shrenkeisen, Editor. Doubleday, Doran & Co., Garden City, 1937: v–vii, 1–185, figs. in text. $1.50.

FISHING FOR BASS, MUSKALONGE, PIKE AND PAN FISHES. By Ray Shrenkeisen, Editor. Doubleday, Doran and Company, Garden City, 1937: vii, 1–181, figs. in text. $1.50.—These last books produced by Schrenkeisen before his recent death, are the collected works of a number of famous anglers. They are of convenient pocket size, and cover the angling lore of all the important fresh water game fishes of America. Many of the chapters are extremely informative for field use, with good sketches illustrating methods of preparing baits, and useful natural history notes.—L. A. WALFORD, *Bureau of Fisheries, Washington, D.C.*

REVIEWS OF THE FISH FAUNA OF THE AMERICAN NORTHWEST.—Dr. Leonard P. Schultz, recently appointed as curator of fishes in the United States National Museum, is to be congratulated on the production of two monographs which summarize his 8 active years of ichthyological research at the University of Washington. Following is a notice of these two works:

KEYS TO THE FISHES OF WASHINGTON, OREGON AND CLOSELY ADJOINING REGIONS. By Leonard P. Schultz. Univ. Wash. Publ. Biol., 2, 1936: 103–228, figs. 1–50.—This set of keys was gradually developed by Dr. Schultz while teaching systematic ichthyology at the University of Washington, and thus was tested repeatedly for adequacy and clarity. It was first issued in mimeograph form (with printed cover) in 1931, and has been considerably revised since that time. The first of the keys is an artificial one to the families, followed by a key to the genera and species of each family. The figures well illustrate the methods of examination and diagnostic characters that might otherwise give the student trouble, and the technical terms are explained in an adequate glossary. The ranges of the 365 forms are stated with accuracy and detail. This work will long remain one of the most useful to students of the fish fauna of the American northwest.

FISHES OF THE AMERICAN NORTHWEST. A CATALOGUE OF THE FISHES OF WASHINGTON AND OREGON, WITH DISTRIBUTIONAL RECORDS AND A BIBLIOGRAPHY. By Leonard P. Schultz and Allan C. DeLacy. Printed in various numbers of the Jour. Pan-Pac. Res. Inst., in Mid-Pac. Mag., 1935: 365–380; and 1936: 63–78, 127–142, 211–226 and 275–290. —Taken with the preceding treatise, this one constitutes a thorough-going systematic, distributional and bibliographic index to our knowledge of the fishes of Oregon and Washington. It shows throughout a high standard of accuracy, a constant attention to detail and a mastery of the literature involved. A large percentage of the records given are original, adding greatly to our knowledge of the distribution of the species of the two states.—CARL L. HUBBS, *University of Michigan, Ann Arbor, Michigan.*

EDITORIAL NOTES AND NEWS

Summary of the 1937 Meeting

THE twentieth annual meeting of the AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS was held in Washington, D. C., from Tuesday evening, May 4, to Saturday, May 8. A meeting of the Board of Governors was held at the Hotel Harrington at 8:15 P.M., May 4, with PRESIDENT GREGORY presiding. Matters of business and policy were discussed, but the only formal action taken was the selection of Honorary Foreign Members, as follows: for 1936, PROF. DAVID M. S. WATSON and PROF. FRANZ WERNER; for 1937, DR. LEO S. BERG and DR. W. WOLTERSTORFF. The CHAIRMAN appointed CARL L. HUBBS, E. R. DUNN, and M. GRAHAM NETTING as a temporary committee on the 1938 meeting to report at the business meeting of the Society.

Sessions of May 5

THE opening session in the U. S. National Museum was called to order by PRESIDENT GREGORY at 10:00 A.M. The Chairman appointed a Nominating Committee, consisting of DRS. TAYLOR, DYMOND, and DUNN, and a Resolutions Committee, consisting of DRS. BLANCHARD, BOGERT, and JOPSON. The following papers were read and discussed:

1. **Notes on the silverhatchet fishes**—Leonard P. Schultz.
2. **On Mexican species of Leptodeira**—Edward H. Taylor.
3. **New fishes from the Continental Tertiary of Alaska**—Erich Schlaikjer.
4. **Anatomy of the ocean sunfish, Masturus**—H. C. Raven.
5. **Data on the natural history of the red-bellied snake, Storeria occipito-maculata (Storer), in northern Michigan**—Frank N. Blanchard.
6. **The origin of the herpetofauna of southern New Jersey**—Carl F. Kauffeld and Robert J. Sim (read by Clifford H. Pope).
7. **Factors determining the time of birth of young in the garter snake, Thamnophis sirtalis**—Frieda Cobb Blanchard and Frank N. Blanchard.
8. **A type of intergradation hitherto unrecognized**—C. M. Bogert.

The morning session adjourned at 12:30. Following luncheon the meeting reconvened at 2:05 P.M., with VICE-PRESIDENT DYMOND in the chair, for the reading of the following papers:

9. **Adaptive radiation of the Dipnoans**—T. S. Westoll.
10. **The independence of red salmon spawning colonies in tributaries of Copper River, Alaska**—Seton H. Thompson.
11. **New and resurrected species of Mexican Amphibia**—Edward H. Taylor.
12. **Some problems in fish distribution in Ontario**—J. R. Dymond and Isobel Limbert.
13. **Life history of Cnemidophorus sexlineatus**—G. K. Noble, William G. Hassler, and H. C. Robertson.
14. **Remarks on a rare Opisthoglyph from Mexico**—C. M. Bogert.
15. **The snake population of eastern Panama (Canal Zone and Darien)**—E. R. Dunn.
16. **The fishes of Gatun and Madden lakes and possible future introductions of food and game fishes**—Samuel F. Hildebrand.

At 7:30 P.M. the members and their guests assembled at the Cosmos Club for the Annual Dinner of the Society. Following an excellent shore dinner the SECRETARY secured the signatures of those present to enclose in a letter to DR. and MRS. MANN expressing regrets for their absence. DR. H. M. SMITH opened the program with a tribute to DR. STEJNEGER who responded in his customary charming manner. DR. GREGORY called for a few "snake" or "fish" stories and the many responses proved that, with due provocation, many of our members can be extremely unscientific. The showing of a Bureau of Fisheries movie of fishing and fish culture concluded the program.

Sessions of May 6

PRESIDENT GREGORY called the morning session to order at 9:15 A.M., for the reading of the following papers:

17. **Ichthyological results of the Petén Expedition**—Carl L. Hubbs.
18. **The resemblances between South American and African Characins**—William K. Gregory and G. Miles Conrad.
19. **Progress in studies of inheritance in fishes.**—Myron Gordon.
20. **Factors influencing taxonomic work among lower vertebrates in North America**—Tracy I. Storer.
21. **On the Mexican forms of Sceloporus**—Hobart Smith.
22. **The osteology of the swordfish, Xiphias gladius**—William K. Gregory and G. Miles Conrad.
23. **Notes on Eastern Acris**—E. R. Dunn.
24. **Common names of North American snakes and reptiles**—A. H. Wright.

Business Session

PRESIDENT GREGORY called the annual business meeting to order at 11:50 A.M. when 40 members, including 19 Governors, were present. By mutual consent the minutes of the previous meeting were dispensed with since they had been published in COPEIA.

The SECRETARY reported that 75 new members were secured in the period of 8 months since the previous meeting; one member died during the period, 8 resigned, and 12 were dropped for non-payment of dues. These changes resulted in a net gain of 54 members thereby increasing the total membership to 454. Twelve new subscribers were added during the period, and 3 were discontinued, which resulted in a net gain of 9 subscribers and increased the subscription list to 97. The total number of members and subscribers was 551 on April 30, 1937. This figure represents a gain of 63 over the previous total, and is the highest figure yet reached by the Society. A geographical analysis of the members and subscribers indicated that 87 copies of COPEIA go to 21 foreign countries, with Canada leading with 24, and Great Britain and the U.S.S.R. following with 9 each. The domestic copies total 464 distributed in 43 states and the District of Columbia; 78 in New York, 54 in California, 41 in Michigan, and 27 in Pennsylvania. The Society has neither members nor subscribers in Delaware, Nevada, Nebraska, South Dakota and Vermont. The SECRETARY expressed his thanks to all of those who had been active in securing new members and particularly to PRESIDENT GREGORY for his extremely energetic work on behalf of the Society.

The TREASURER announced that financial reports had been switched to a calendar year basis, and he read the report for the year 1936.

DR. HUBBS presented an informal editor's report and explained the necessity of relinquishing the ichthyological editorship in which he had labored to such good effect since 1930.

The 75 new members proposed during the year were formally elected. The SECRETARY announced the names of the HONORARY FOREIGN MEMBERS chosen by the Board of Governors. There were no reports from standing committees.

The 1938 Meeting Committee announced that invitations had been received from Shedd Aquarium, the University of California, Louisiana State University, and the Royal Ontario Museum of Zoology. The Committee further reported that in view of the active desire of western members to have a meeting held closer to their center of membership that the invitations from the institutions in Baton Rouge and Toronto be tabled for consideration for some subsequent year. DR. HUBBS formally moved that the Board of Governors be asked to vote upon a 1938 meeting at either Berkeley or Chicago. This motion was passed.

DR. GUDGER moved that papers at future meetings be limited to 15 minutes, and that no person be permitted to present a second paper until each individual on the program had presented one paper. After considerable discussion, this motion was defeated. The Nominating Committe presented its report and the SECRETARY was asked to cast a ballot electing the following officers: JOHN T. NICHOLS and LEONHARD STEJNEGER, *Honorary Presidents;* WILLIAM K. GREGORY, *President;* L. M. KLAUBER, LEONARD P. SCHULTZ, and HOBART M. SMITH, *Vice-Presidents;* M. GRAHAM NETTING, *Secretary;* ARTHUR W. HENN, *Treasurer;* HELEN T. GAIGE, *Editor-in-Chief* of COPEIA; LIONEL A. WALFORD, *Ichthyological Editor;* KARL P. SCHMIDT, *Herpetological Editor.*

The Business Meeting was adjourned at 12:30 P.M. and members assembled for luncheon in the Dept. of Commerce building. Following this, the group visited the U. S. Bureau of Fisheries Aquarium in the same building. The afternoon session convened at 2:15 P.M., with VICE-PRESIDENT BLANCHARD presiding for the reading of the following papers:

25. **A review of the genus Coniophanes**—Joseph Bailey.
26. **The dispersal of some monotypic snake genera in the United States**—M. Graham Netting.
27. **The appendages of the caudal vertebrae of snakes and their sexual differences**—William H. Stickel.
28. **Eggs and natural nests of the eastern ringneck snake, Diadophis punctatus edwardsii**—Frank N. Blanchard.
29. **Pattern evolution in the Colubrid, Sonora michoacanensis**—William H. Stickel.
30. **Notes toward a history of treatment for snake bite (vipers and rattlesnakes)**—Tracy I. Storer.
31. **Fishes of isolated basins in the Western United States**—Carl L. Hubbs.
32. **Melanin dispersion and choice of background in fishes, with special reference to Ericymba buccata**—Frank A. Brown, Jr. and David H. Thompson (summary read by the secretary).

Program of May 7

SOME of the members participated in a field trip to Zekiah Swamp and to a cypress swamp (Battle Creek), both in Maryland. At 8:00 P.M. the members and their guests attended an informal smoker in the Mammal Range of the U.S. National Museum, given by the Local Committee of the American Society of Mammalogists. Refreshments and conversation made the gathering a most enjoyable one.

Program of May 8

MEMBERS joined with the American Society of Mammalogists in viewing the National Zoological Park under the guidance of MR. ERNEST P. WALKER, Acting Director. Following the morning tour, a complimentary luncheon was served in the Pachyderm House at 1:00 P.M. The meeting formally closed following this luncheon, although some members remained to view additional exhibits at the Zoo.

At the conclusion of the meeting the Committee on Resolutions presented the following resolutions, the first of which was subsequently transmitted by the SECRETARY to the various hosts who arranged the meeting.

Whereas, the American Society of Ichthyologists and Herpetologists has just experienced a most successful and pleasurable meeting here in Washington, therefore,

Be it resolved, that the Society hereby extends its thanks and appreciation to the authorities of the United States National Museum, and of the National Zoological Park, and to the Local Committee of the Society, and to the Local Committee of the American Society of Mammalogists for the efforts and courtesies which have effected such success.

And: *Whereas* our journal, COPEIA, during the past seven years, has thrived exceptionally under the able, untiring and enthusiastic editorship of Carl L. Hubbs, who now feels it necessary to resign from this work,

Be it hereby resolved that the Society express its gratitude to him, and its regret at loss of his services in this capacity.

It is a source of regret to the SECRETARY that the Local Committee insisted upon remaining anonymous, but every member who attended deeply appreciated the excellent work of preparation which was done by the Committee.

The total signed registration during the meeting was 84.

Herpetological News Notes

CLIFFORD POPE is joining ROBERT T. HATT, Mammalogist, for a survey of the distribution of vertebrates of the Manitou and Fox islands of Lake Michigan. Other members of the party in its first season's work will study the geology of the islands in relation to possible former land connections. The party, which this year will operate in June and July, is under the auspices of the Cranbrook Institute of Science.

THE SOCIETY extends congratulations to PROF. FRANZ WERNER, one of our recently elected Honorary Foreign Members, on the coming celebration of his seventieth birthday, August 17. Prof. Werner has a fine record as an educator, having taught in the Zoological Institute of the University of Vienna from 1895 to 1933, when he became emeritus, as an enthusiastic and able explorer and as a distinguished researcher.

His wide interests are shown by his lengthy list of publications which includes not only herpetological items but also titles on Orthoptera and scorpions. We are indebted to Dr. Walter Mosauer for the loan of the photograph of Prof. Werner.

Mexican expeditions this summer include one to Chiapas, by DR. NORMAN HARTWEG and DR. PIERCE BRODKORB (ornithologist), of the Museum of Zoology, University of Michigan.

Ichthyological News Items

THE SOCIETE NATIONALE D'ACCLIMATATION DE FRANCE has awarded its 1936 silver medal to DR. GEORGE S. MYERS, in recognition of his researches on fishes, particularly the smaller fresh-water species. The presentation was made by M. Albert Lebrun, President of the French Republic.

DR. RICHARD WEISSENBERG, long a member of the medical staff of the University of Berlin, is spending the year as visiting professor of cytology at the School of Medicine of Washington University, St. Louis. He is undertaking investigations of lymphocystis in American fishes.

ALFRED C. WEED and LEON PRAY, of the Field Museum, are spending several weeks this summer collecting fishes in the vicinity of the University of Maine Biological Station at Lamoine, Maine.

Fisheries research in Ohio has been centered at the Franz Theodore Stone Laboratory on Gibraltar Island, Lake Erie. DR. T. H. LANGLOIS is in charge of this work as well as of fish culture. Courses and research in fish management are being stressed at the laboratory. The instructional staff this summer comprises VICTOR E. SHELFORD, BERNARD S. MEYER, CLARENCE H. KENNEDY, RAYMOND C. OSBURN, and C. J. D. BROWN. DR. BROWN, at the close of the summer's work, will join the staff of the Institute for Fisheries Research at the Museum of Zoology, University of Michigan.

Fisheries biologists interested in the study of the Pacific sardine met for a conference at the California State Fisheries Laboratory, Terminal Island, the week of May 17. J. L. HART, of Canada, LLOYD ROYAL, of Washington, VERNON BROCK, of Oregon, and O. E. SETTE, of the Bureau of Fisheries, were present, as well as the entire research staff of the California Laboratory.

Recent Deaths

RICHARD CRITTENDEN MCGREGOR died at Manila, P. I. on December 30, 1936, at the age of 65. At the time of his death he was Chief of the Division of Publications and Agriculture of the Philippine Islands. Born at Sydney, Australia, February 24, 1871, McGregor received his A.B. at Stanford in 1898. Although his primary interest was Ornithology, he has left some memorable work in the field of Ichthyology, having been associated with the Hopkins Expedition to Panama in 1896 and the Anthony Expedition to Lower California in 1897. He became Ornithologist for the Bureau of Science, Philippine Islands, in 1901, and Associate Editor of the Philippine Journal of Science in 1919.

LUCY WRIGHT SMITH CLEMENS, who died on May 23, 1937, will be remembered by those who did not have the pleasure of knowing her, for her collaboration with her husband, Wilbert A. Clemens, in contributing to our knowledge of the life history of the sockeye salmon. Dr. Clemens was born in Sheffield, Massachusetts, January 3, 1887. She received her A.B. from Mt. Holyoke College in 1909, her M.A. in 1911, and her Ph.D. in 1914 at Cornell. At the time of her death she was associated with the Pacific Biological Station, Nanaimo, British Columbia.

RICHARD WHITE WEHRLE, a jeweler of Indiana, Pennsylvania, died on July 4, 1937, at the age of 84 years. In addition to being the nestor of natural science in Indiana County, Mr. Wehrle collected specimens of the salamander which perpetuates his name, *Plethodon wehrlei*. Mr. Wehrle donated hundreds of specimens to the Academy of Natural Sciences and to the Carnegie Museum, and his unwaning interest in herpetology is evidenced by a card dated April 7, 1937, stating "I sent this day 9 DeKay's Snakes plowed up under a heavy grass sod."

News has just been received of the death of DR. WALTER MOSAUER, at Mexico City, on August 10. He was stricken with leucemia in Acapulco, where he was continuing his earlier investigations on the reptile-amphibian fauna of that area. Dr. Mosauer was a graduate of the University of Vienna, coming from that institution to the University of Michigan, where he taught anatomy and was granted his Ph.D. For a number of years he has been a member of the zoology staff of the University of California at Los Angeles. His fine training in anatomy made especially valuable his studies on the movements of reptiles, and his engaging and vital personality made for him many friends in America.

Support of Copeia

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